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NEUROLOGICAL AND PHYSIOLOGICAL STUDIES ON DISTILLED AND BREWED BEVERAGES

BY

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HELSINKI, FINLAND

FROM THE NEUROPSYCHIATRIC CLINIC OF THE UNIVERSITY
OF HELSINKI, CHIEF: PROFESSOR MARTTI KAILA, M. D.
and
FROM THE INSTITUTE OF OCCUPATIONAL HEALTH, HELSINKI,
CHIEF: PROFESSOR LEO NORO, M. D.

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MAALAISKUNTIEN LIITON KIRJAPAINO

PREFACE

On the completion of the study reported in this book it is my pleasant duty to record my indebtedness to a number of persons and institutions, above all to the Finnish Foundation for Alcohol Studies.

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Helsinki, March, 1957.

T. A. P.

CONTENTS

Page

1 INTRODUCTION AND REVIEW OF EARLIER INVESTIGATIONS.. 7
11 Introduction 7
12 Effects on blood alcohol..... 8
121 Various dilutions of different beverages 8
122 Distilled and brewed beverages..... 9
123 The descent of the blood alcohol 12
13 Effects on circulation 12
14 Effects on nervous functions 14
141 Various dilutions of different beverages 14
142 Distilled and brewed beverages..... 15
2 ARRANGEMENT OF THE PRESENT INVESTIGATION 19
21 On the aims of the investigation 19
22 Formulation of the problems..... 19
23 Experimental procedure 20
231 The experimental series:
Preliminary series — A_1 series — A_2 series — B series — C series — Cerebrospinal fluid group 20
232 The experimental subjects 23
233 Time of the experimental sessions 25
234 The experimental beverages and their dosage 26
24 Statistical analysis 27
241 The description of observations 27
242 Comparisons between experimental series 27
243 Accounting for the effect of training 29
244 Graphical representation 32
3 EXPERIMENTS AND RESULTS 33
31 Blood alcohol and related observations 33
311 Blood alcohol:
Method — Preliminary series — A_1 series — Peak level — Range of variation — Individual observations — Synopsis 33
312 Alcohol content of the cerebrospinal fluid 44
313 Blood alcohol in the C series 47
32 Circulation 49
321 A_1 series:
Pulse rate — Blood pressure — Colour of the face 49
322 C series 53
33 Metric observations on nervous functions 54
331 Nervous functions recorded in earlier investigations 55
332 Static ataxia. Swaying:
Method — Results — Synopsis..... 56
333 Manual coordination. Finger-finger test:
A_1 series — A_2 series — Dynamometer test (C series) 63
334 Manual dexterity:
Method — Uncorrected results — Corrected results — Range of variation — Range of variation of changes — Condensed findings — Synopsis 68

335 Finger dexterity:
Method — Uncorrected results — Corrected results — Range of variation — Range of variation of changes — Condensed findings and synopsis ... 76
336 Intellectual performance:
Method — Uncorrected results — Corrected results — Range of variation — Range of variation of changes — Condensed findings and synopsis ... 81
34 Clinical observations ... 87
341 Disturbance of speech ... 88
342 Mood of the subjects:
A_1 series — C series ... 89
343 Physical sensations:
A_1 series — C series ... 91

4 A STUDY ON THE MOTILITY OF THE STOMACH ... 94
41 Earlier investigations ... 94
42 Method ... 97
421 The experimental beverages and their dosage ... 97
422 Roentgenological examination ... 98
423 Blood alcohol determinations ... 98
43 Roentgenological observations ... 98
431 X-ray reports ... 99
432 Condensed roentgenological findings:
Pylorospasm — Filling of the bulb — Evacuation of the stomach 103
44 Blood alcohol ... 105
45 Experiments with alcohol solution ... 106
46 Synopsis ... 107

5 DISCUSSION ... 111
51 The experimental beverages ... 111
511 Alcohol content ... 111
512 Carbohydrates, proteins, vitamins and other congeners ... 112
513 Carbon dioxide ... 114
514 Water quantity ... 114
515 On electrolytes and hypotonicity ... 116
516 pH and buffer capacity ... 116
52 Nervous disturbances and blood alcohol ... 117
521 Earlier experimental results ... 118
522 Present findings ... 120
53 Combination of results, and conclusions ... 124
531 Blood alcohol:
A_1 series — B series — C series — Cerebrospinal fluid group ... 124
532 Motility of the stomach ... 127
533 Circulation ... 129
534 Nervous functions:
Static ataxia — Manual coordination — Manual dexterity — Finger dexterity — Synopsis of sensomotor functions — Intellectual performance ... 131
535 Clinical observations:
Mood of the subjects — Physical sensations — Disturbance of speech — Colour of the face ... 137

6 SUMMARY:
Blood alcohol — Motility of the stomach — Circulation — Static ataxia. Swaying — Manual coordination. Finger-finger test — Manual dexterity — Finger dexterity — Intellectual performance — Clinical observations 139

7 BIBLIOGRAPHY ... 143

8 APPENDIX ... 149

1. INTRODUCTION AND REVIEW OF EARLIER INVESTIGATIONS

11. INTRODUCTION

In recent years alcohol research has mainly followed two particular paths of investigation. On the one hand, more developed procedures such as the use of alcohol labelled with a radioactive carbon isotope have been enlisted in the search for deeper and more precise knowledge of the numerous still unclarified points in the metabolism of alcohol. On the other hand, the study of inebriation has aimed at determining the effects of alcohol on important functions of everyday life, e.g., on the ability to control a vehicle. Social politics and forensic psychiatry have also called upon alcohol research to solve some of their problems.

A problem group which has continuously gained in practical significance is comparison between distilled and brewed beverages in regard to their effects upon man. In some investigations, attention has been paid to the metabolism of the beverages, while others have been concerned with the nervous and psychic disturbances they may cause, aiming at the characterization and quantitative evalution of the differences observed in this respect.

In many respects the results of the experimental investigation are in good agreement, but discrepancies are observable as well. They are mainly attributable to differences in procedure, but in some instances erroneous and imperfect treatment of the results or excessive generalizations are their likely cause.

Since most experiments have differed with regard to method as well as to the amount and kind of alcohol ingested, direct comparison of their results has been possible only in rare instances.

12. EFFECTS ON BLOOD ALCOHOL

In the studies relating to the metabolism of alcohol, the attention has mainly been centred on the variations of the blood alcohol. In particular, the rate of its increase, the height and the time of attainment of its maximum, and the distribution of the alcohol in the body as well as its elimination have been objects of study.

121. VARIOUS DILUTIONS OF DIFFERENT BEVERAGES

Numerous investigators have performed experiments in order to determine the effects of absolute alcohol in various dilutions on the concentration of alcohol in the blood, and they have partly arrived at contradictory results. Absence of any distinct effect upon the concentration of alcohol in the blood and urine from the dilution of alcohol ingested on an empty stomach has been reported by WIDMARK (1916). MELLANBY (1919) found that the preceding intake of water accelerated the rate of alcohol absorption in contrast with SOUTHGATE (1925), who did not observe any effect. A higher rate of absorption was observed by TUOVINEN (1927) in the case of dilute 4 and 10 per cent alcohol solutions than with high concentrations (40 and 60 per cent). A 60 per cent alcohol solution appeared to be rapidly absorbed at first, the rate of absorption abating later on, whereas a 40 per cent solution was absorbed slowly in the beginning, but finally resulted in a higher blood alcohol level than the 60 per cent solution. Strong solutions seemed to produce a curve with a slower decline than weak solutions. The said author was not inclined to generalize these results, but rather suspected that they might be individual. Later, in a more extensive study, TUOVINEN (1930) arrived at results according to which dilute alcohol solutions (5 and 20 per cent) taken on an empty stomach produced a higher blood alcohol level after 20 and 60 minutes than strong solutions (40 and 60 per cent). In some cases, however, the concentration at 60 minutes was higher with a strong solution than with a dilute solution. The subsequent course of the blood alcohol curves was approximately the same in both cases. It should be

noted that the strong solutions used by TUOVINEN were of considerably higher concentration than those used as a rule in experiments of this kind.

Diluting whisky with water altered the blood alcohol curves towards greater resemblance of the »overshooting» form (HAGGARD, GREENBERG and LOLLI 1941).

Several other investigators have arrived at different results. MELLANBY (1919), in his experiments on dogs, observed that a 20 per cent alcohol solution caused a higher blood alcohol and an earlier attainment of its maximum than a 5 per cent solution. Similar findings are reported by MILES (1922), who noted that strong alcohol solution (27.5 per cent by volume) produced a higher blood alcohol in comparison with a more dilute solution (2.75 per cent by volume), which gave a lower alcohol curve with a later, less distinct maximum. According to SCHMIDT (1937), equivalent alcohol dosage (0.75 g per kg) resulted in slightly higher blood alcohol figures and in an earlier attainment of the maximum when used in stronger solution, although the difference was not essential in SCHMIDT's opinion.

Among later investigators, GOLDBERG (1951), for instance, noted at a comparison of strong spirits of 31.7 per cent by weight and of an alcohol solution of 2.6 per cent by weight that the maximum blood alcohol value remained about 20—30 per cent lower and the peak was also less pointed in the latter case, but in their later course both curves maintained the same level.

122. DISTILLED AND BREWED BEVERAGES

A comparison between beer and whisky has been instituted by MELLANBY (1919) with dogs as experimental animals. Whisky of 28.5 per cent by volume yielded a blood alcohol curve on a higher level than beer of 3.9 per cent by volume, if equal absolute alcohol quantities were administered in either case. Beer of 5.5 per cent by volume merely produced a lower maximum than whisky, but otherwise the curves maintained the same level. Dilution of the strong beverage resulted in a decrease of the maximum and delay of its attainment.

According to the results of HAMMARSTEN and LILJESTRAND

(1922), beer of 2.6—3.6 per cent by weight had to be used in dosages equivalent to an amount of alcohol greater by 20—30 per cent in order to obtain a blood alcohol equal in level to that caused with brandy of 45—50 per cent by weight. When equivalent doses of alcohol were given in the form of whisky diluted with an equal volume of soda water and in the form of beer containing 5 per cent alcohol, the blood alcohol was lower by 15—20 per cent with beer than with whisky in the experiments of SOUTHGATE and CARTER (1926).

A different result was obtained by KIONKA (1927), who found no difference in the alcohol curves when one and the same alcohol quantity was ingested as beer of 3 per cent and as brandy of 45 per cent.

With French brandy, SCHAACKE (1938) obtained in most cases a higher blood alcohol than with beer when the alcohol quantity was the same in both cases. Also when brandy and beer were ingested together, the blood alcohol was higher than when an equivalent alcohol quantity was ingested as beer. Beer has furthermore been compared to whisky and gin by HAGGARD, GREENBERG and COHEN (1938), to neat and diluted whisky and Martini cocktail by HAGGARD, GREENBERG and LOLLI (1941), and to strong and diluted liquor by GOLDBERG (1951). All these investigators have obtained a lower blood alcohol curve with beer than with the distilled beverage under comparison. HAGGARD, GREENBERG and LOLLI observed that beer produces an alcohol curve of much longer duration than whisky. In the investigations of GOLDBERG (1951) with identical alcohol quantities ingested as beer of 1.9—3.2 per cent by weight and as brandy of 31.7 per cent by weight, the blood alcohol curve rose more slowly with beer than with brandy, and the maximum of the blood alcohol remained 30—50 per cent lower in the experiment with beer. The overall level of the blood alcohol was also lower by 15—25 per cent in the beer experiment.

ALHA (1953) did not observe any definite difference in blood alcohol between experiments with beer and brandy on six subjects, the alcohol dosage being 0.5 g of absolute alcohol per 1 kg of body weight taken on an empty stomach within 5 minutes. According to the investigator the absorption in the beer series was possibly slightly slower than in the brandy series, but no definite differences could be established.

MELLANBY (1919) as well as HAGGARD et al. (1941) and GOLDBERG (1951), in their experiments, have also diluted the strong beverage employed to a concentration corresponding to the alcohol content of the brewed beverage which was the subject of comparison. However, this resulted invariably in a more or less steeper and greater rise of the blood alcohol curve in the experiments than was obtained with the brewed beverage.

The slower absorption of beer has been attributed by some investigators (MELLANBY, GOLDBERG) to some as yet unknown constituents of the beer. The absorption of beer has also been compared with that of distilled beverages taken together with food.

According to the investigations of TUOVINEN (1930), the retarding effect of foodstuffs on alcohol absorption has respect primarily to the mixed meal and to the proteins and carbohydrates, less to the fats (see also p.112). A mixed meal, according to HAGGARD et al. (1941), had a delaying effect when ingested with whisky and Martini cocktails, but no noteworthy effect in connection with beer. Similar results are reported by GOLDBERG from experiments with brandy taken together with food, the alcohol curve assuming in this case a resemblance to that produced by beer, whereas food ingested together with beer (2.6 per cent by weight) hardly affected its blood alcohol curve.

Some investigators have attributed the slower rate of absorption of brewed beverages to delayed emptying of the stomach (e. g. HAGGARD et al. 1941), but sufficient proof of a different effect of distilled and of brewed beverages upon the motility of the stomach (see page 94—97) has not been encountered in the literature (cf. GOLDBERG 1951).

The majority of the investigators has thus arrived at the result that strong, distilled beverages as a rule cause a higher rate of increase and a greater absolute increase of the blood alcohol than is obtained at the ingestion of an equivalent alcohol dosis in the form of a weak solution or of a brewed beverage. This is in agreement with the observation that the absorption of alcohol follows the law of diffusion (BERGGREN and GOLDBERG 1940). However, the dilution factor alone cannot account for the results from the experiments with brewed beverages, since a different result has been obtained with an aqueous alcohol solution of equivalent concentration, as has been stated in the foregoing.

123. THE DESCENT OF THE BLOOD ALCOHOL

The experimental results of MELLANBY (1919) and WIDMARK (1932), according to which the rate of alcohol elimination is independent of the amount of alcohol ingested and of the blood alcohol level, have been checked by numerous investigators. Many of them have arrived at results supporting the so-called Widmark theory (JUNGMICHEL 1933, BERNHARD and GOLDBERG 1935, NEYMARK and WIDMARK 1936, NEWMAN and LEHMAN 1937, SCHMIDT 1937, CLARK, MORRISSEY, FAZEKAS and WELCH 1941, BARTLETT and BARNET 1949. LOOMIS 1950[1]), ALHA 1951, THEORELL 1952), but also differing results have been noted (HAGGARD and GREENBERG 1934, NEWMAN, LEHMAN and CUTTING 1937, EGGLETON 1940, HAGGARD, GREENBERG and LOLLI 1941, CUTTING, NEWMAN and YEE 1949, GOLDBERG 1951, VITALE et al. 1953, MARSHALL and FRITZ 1953).

In their surveys on the metabolism of alcohol, JACOBSEN (1952), JUST (1952) and SEIFERT (1955) consider Widmark's theory valid »in practice» as regards the linear decline of the blood alcohol curve, but they concede that its rate depends to some extent on the blood alcohol level.

The shape of the descending part of the blood alcohol curve has been explained as dependent on the varying degree of participation of different fermentation systems in the combustion of the alcohol. Under the influence of alcohol dehydrase a linear curve is obtained, which may assume a slightly hyperbolic character, possibly according to the degree in which the catalase reaction is involved as well (cf. JACOBSEN).

GOLDBERG (1951), in his investigation on brewed beverages, has observed an accelerated rate of elimination of beer alcohol as compared with the elimination of the alcohol in brandy. ALHA (1953) could not reproduce this result in his experiments with Finnish brandy and beer.

13. EFFECTS ON CIRCULATION

Numerous observations exist concerning the acute effects of alcohol on the blood circulation. In a majority of the cases, however, the results of experiments are not mutually comparable. Very few reports are available on the effects, and differences in effect, of various kinds of alcoholic beverages.

An increase of pulse rate or blood pressure, or both, with small dosages of alcohol has been observed by several investigators

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[1]) In a certain concentration range only.

(e.g. DODGE and BENEDICT 1915, MILES 1924, GROLLMAN 1930, 1942, ALHA 1951), while high dosage has been found to reduce the arterial pressure, particularly the systolic pressure, and the pulse amplitude (e.g. MAYER 1936, SOLLMANN 1950)

The effect also seems to depend on the method of administration. At oral ingestion an increase of blood pressure, particularly of pulse amplitude, could be observed (BROOKS 1910), whereas at intravenous administration an abrupt fall of blood pressure and a marked slackening of the pulse resulted. These effects subsided very soon unless an excessive dosis was used.

Varying results have been obtained in earlier and later experiments with animals, with different alcohol dosages, by numerous other investigators (e.g. LIEB 1915, MCDOWALL 1925, MACHNE 1950, LASKER and SHERROD 1953, SMYTHE, HEINEMANN and BRADLEY 1953). Of these, LILJESTRAND (1953) studied the effect of alcohol upon the vasoreflexes of the carotid body.

According to GROLLMAN, 15 ml of alcohol (40 per cent solution) do not affect the circulation in most people. Any changes which may be observable are reflectory and caused by irritation in mouth and throat. A »moderate» dosage (35 ml) causes an increase of pulse rate, blood pressure and minute volume. The increase of the pulse rate, about 4 systoles per minute, appears 15 to 30 minutes after ingestion of the alcohol. GROLLMAN, however, considers the pulse rate a function of such unstability that its changes carry no great weight.

According to SOLLMANN, dosages of 45—90 ml at first increase the blood pressure, but after one hour at the latest there ensues a progressive fall of the systolic pressure and a decrease of the pulse amplitude, while the diastolic pressure remains constant. This effect should be attributable to vasodilation in the splanchnic circulation preceded by vasoconstriction.

Decrease of blood pressure has been observed also with high alcohol dosage by MAYER. In his experiments dosages of 1—1.68 g per kg of body weight had a distinct effect on blood pressure. The systolic pressure decreased more than the diastolic pressure, causing a decrease of pulse pressure.

ALHA observed an increase in pulse rate attaining its maximum 15 minutes after the ingestion of alcohol.

The vasodilatory effect of alcohol, and its effect upon blood flow, in various organs has been studied by numerous investigators (e.g. MCDOWALL 1925, SCHULZE 1947, HALONEN, VAR-

TIAINEN and VENHO 1951, HINE et al. 1952, BATTEY, HEYMAN and PATTERSON 1953, MENDELOFF 1954, etc.). Dilation of cutaneous vessels is commonly known (e.g. COOK and BROWN 1932). The effect has been found to depend also on the potential congeners of the alcoholic beverage (VARTIAINEN, VENHO and VAPAAVUORI 1953). VARTIAINEN et al. have established the dilating effect of old French brandy upon the coronary arteries as exceeding that of pure ethanol.

Most investigators have observed that alcohol in general causes vasodilation of the skin and initially accelerates the pulse, although this effect has not manifested itself if a sufficiently dilute solution was used. Some authors have observed a mild decrease in systolic and pulse pressure, in particular with greater doses. As a rule these effects have been considered mainly reflectory as to their mechanism. (See, e.g., the surveys of STARLING et al. 1923, GORDONOFF 1934, WADDEL and HAAG 1940, HAGGARD and JELLINEK 1950, SOLLMANN 1950.)

No established differences in effect between distilled and brewed beverages have been encountered in the literature. The investigations on the circulatory effects of brewed beverages mostly relate to their chronic use.

14. EFFECTS ON NERVOUS FUNCTIONS

In this connection the most important previous investigations will be reviewed without any detailed reference to the methods employed in each case nor to the general problems of the methodics which are encountered in studies of this kind (cf. p. 54).

141. VARIOUS DILUTIONS OF DIFFERENT BEVERAGES

The effect of a 10 per cent and a 30 per cent alcohol solution (total alcohol dosis 30 cc.) upon the abilities of learning, of comprehension and of performing additions, on the association ability, on the performance in the choice reactions and on dexterity was investigated by GYLYS (1927) in Kraepelin's laboratories. A stronger solution had a more marked effect on the abilities of performing additions, of learning and comprehension. Also, the

number of real associations decreased while the number of senseless associations increased. A more dilute solution had a stronger effect on dexterity performance, prolonging the reaction time in the choice reactions as well as in the associations. The investigator arrived at the result that strong solutions cause stronger disturbance of intellectual functions, whilst motor reactions are more strongly disturbed by dilute solutions. The difference in reaction time was similarly typical of the effects: with weaker solutions the impairment of the results continued until the end of the experiment, whereas in the case of a stronger solution an improvement of the results was observable during the later phase of the experiment. The investigator attributed the differences to differences in the absorption and combustion of alcohol.

The effect of various degrees of alcohol dilution on precision was investigated by TUOVINEN (1927) with a »needle-threading» test and he noticed an earlier onset of the effect with a dilute solution (10 per cent) than with a stronger solution (60 per cent). The effect of a stronger solution was more marked in a person unaccustomed to the use of alcohol, but this difference diminished when the subject got used to alcohol.

NEWMAN and ABRAMSON (1942) studied the differences in the effect of whisky and wine and found that whisky caused a more rapid and more marked disturbance of coordination than wine; this difference disappeared when glucose was added to the whisky. Wine caused an equally marked impairment of coordination only if the blood alcohol exceeded that produced with distilled beverages.

142. DISTILLED AND BREWED BEVERAGES

In their comparisons of the effects of beer and brandy, HAMMARSTEN and LILJESTRAND (1922) estimated the intoxication disturbances by means of the standard and modified Romberg tests and by other means, but their summary recording method was not sensitive enough to allow of an adequate evalution of the difference.

The effects upon precision (threading a needle) of beer of 2.7 per cent by volume, or less, have been investigated by TIGER-

STEDT, VARTIA, LOVESON and KORHONEN (1924). The dosage was 2 litres taken during 30—35 minutes with a meal, and only the strongest beer was found to have an effect on the performance.

GRAF (1928 and 1930) investigated the effect of different kinds of beverages on dexterity performance by giving 40 g of alcohol as beer, wine and French brandy, respectively. Beer caused a relatively slow impairment of the performances; after about one hour a temporary improvement of the performance (»under the influence of motoric irritation») was observed. French brandy caused a steeper decline, but after more than one hour a slight temporary improvement could be noted in this case as well. The recovery was very rapid in the experiment with French brandy as compared with the beer experiment. GRAF attributed this to differences in the absorption of the various beverages.

The effect of beer and brandy on driving ability has been studied by BJERVER and GOLDBERG (1950). The experimental subjects (37 altogether) were divided into a beer series and a brandy series, and these again into an alcohol and control series both. In the experiments 3—4 bottles of beer were taken, equivalent to an alcohol quantity of 37—49 g., i.e., 0.52—0.72 g per kg of body weight. The percentage of the beer was 3.2 per cent by weight. Brandy was ingested in an amount of 10—13 cl, equivalent to 31.7—41.1 g of alcohol, i.e., 0.37—0.69 g per kg of body weight. On the average, 0.60 g of alcohol per kg were ingested in the beer series, and 0.52 g per kg in the brandy series. In the beer series the blood alcohol concentration after 74 minutes was, on the average, 0.46 per mil, and in the brandy series 0.49 per mil at 61 minutes. Various driving tests were performed and the time of performance was measured, and the results were compared to the results of the control series. In the alcohol series an impairment of judgement and increase of self-confidence could be observed, as well as nonchalance, to a certain extent. Alcohol was observed to cause a prolongation of the driving time, thus impairing the performance. The impairment ranged from 3.3 to 71.8 per cent, with a mean of 27.9 per cent. In the beer series the mean impairment was 18.6 per cent, and in the brandy series 32.7 per cent. The investigators interpreted the differences as being most likely due to differences in the

concentration of alcohol in the blood, although the level of significance of these differences has not been established.

In an extensive study, GOLDBERG (1951) has presented results concerning the effects of beer of 1.9, 2.6 and 3.2 per cent by weight, also comparing them with results obtained with distilled spirits (e.g. 1943) He performed the flicker fusion test, the cornea reflex test, the quantitative Romberg test and the finger-finger test etc. Psychic functions were investigated by means of the subtraction test and the Bourdon test. The flicker fusion test appeared to be most sensitive. The effect was most marked when the blood alcohol curve had reached its maximum. In some cases the effect disappeared more rapidly than the blood alcohol curve fell; in some others, however, the effect could still be observed after the alcohol had disappeared from the blood.

According to the results of GOLDBERG, the logarithms of the intoxication symptom figures showed a linear dependence of the blood alcohol both in the brandy and the beer experiments. For practical reasons the investigator has presented only the results of the flicker fusion and cornea reflex tests; he states that the results of the other tests confirm these results.

ALHA (1953) has compared the effects of brandy and of beer upon the performance of stenographers. The results indicate that beer seems to produce a stronger and more prolonged disturbance to stenography than brandy.

The effects of beer upon some nervous function have been investigated even by some other investigators with the aid of quantitative methods (e.g. JOSS 1900, CARLSON et al. 1934), but an earlier comparison between the nervous effects of distilled and brewed beverages scarcely occurs except in the publications of GRAF, BJERVER and GOLDBERG, of GOLDBERG and of ALHA. The results obtained by these investigators are not in agreement in every respect, as has been shown above. According to GRAF, BJERVER et al. and GOLDBERG, the quantitative effect of beer on the nervous functions is inferior to that of distilled beverages. On the other hand the effect of beer on a certain function (stenography) was greater according to ALHA, whose results, however, have been commented by TAKALA (1953).

In one respect these investigators have observed similar effects: According to GRAF the disturbance of coordination had a longer

duration when caused by beer than when caused by French brandy. Similarly, ALHA noticed that the disturbing effect of beer lasted longer than that of brandy. GOLDBERG has even observed in some cases that the disturbances caused by beer continued after the alcohol had disappeared from the blood.

An extensive psychological comparative investigation with the same beverages as have been used in the present work has been carried out by TAKALA (TAKALA et al. 1957).

Although numerous even quite extensive investigations have been performed, there is still uncertainty as to the potential differences between distilled and brewed beverages in their effect upon varions functions of the nervous system, for instance the sensomotor and intellectual functions.

2. ARRANGEMENT OF THE PRESENT INVESTIGATION

21. ON THE AIMS OF THE INVESTIGATION

The purpose of this investigation is to institute a comparison between the effects on some functions of the nervous system of a distilled beverage (blended brandy of 32.6 per cent by weight) and a malt beverage (class III beer of 3.6 per cent by weight) in a manner set forth in detail in the next chapter.

This study also concerns itself with the blood alcohol, primarily with its rate of increase and its approximate maximum, whereas no study of its elimination is intended. Attention will also be paid to the effects on circulation.

During the progress of the work, furthermore, a comparative study of the motility of the stomach has been included, in the first place with a view to comparing the rates of evacuation of the stomach in the brandy and beer experiments and noting the possible occurrence of pylorospasm.

22. FORMULATION OF THE PROBLEMS

The following questions are the main concern of the present study:

What time relation does the blood alcohol show in experiments with brandy and beer under identical conditions on one and the same experimental group, both beverages being taken in a quantity equivalent to 1 g of absolute alcohol per kg body weight, and what differences can be observed between the beverages in this respect?

Is any difference observable in the effect of the above-mentioned beverages on some functions of the circulation?

Is there any difference in the effects of these beverages on some sensomotor reactions and on intellectual performance?

Does clinical evalution reveal any difference between the effects of these beverages with regard to speech motorics, the mood, and certain physical sensations of the experimental subject?

Does roentgenological investigation reveal any difference in the motility of the stomach in similar brandy and beer experiments?

Originally the study concerned only the first four questions. However, as soon as the results on these points were available, it appeared well motivated, particularly in view of the observed behaviour of the blood alcohol, to pay closer attention to the motility of the stomach, using the same beverages in the same dosage. This was considered particularly interesting inasmuch as the literature presents controversial or still inadequately confirmed opinions with regard to the resorption of beer and to the potential contribution of changes in the motility of the stomach to the same.

Questions concerning the alcohol in the cerebrospinal fluid are not mentioned among the problems. Such observations as have been made relating to this subject have been treated merely as accessory material.

The experimental series referred to later as the C series, in which the effects of beer and of an alcohol solution of 3.2 per cent by weight, and of water, upon some functions have been compared, does not aim at an independent objective, but rather furnishes the material for a supplementary consideration bearing on the effects of beer.

23. EXPERIMENTAL PROCEDURE

In consequence of the multilateral problems taken under consideration in this work, it has been necessary to carry out the experiments in several series. Even so, the various recording tasks involved an ample amount of work, for which reason certain restrictions were unavoidable, for instance, with regard to the consistent use of control groups.

With a view to judgement of the results obtained in this work, there is reason to give in the following a detailed account of the composition of the various experimental groups and of the experimental arrangements in each case.

231. THE EXPERIMENTAL SERIES

Preliminary investigation. — A preliminary investigation was carried out at the planning stage of this work, the experiences gained being used as a guide to the final research plan.

A_1 series. — This series constitutes the actual comparison between the states of intoxication produced with brandy and with beer, respectively, attention being centred on blood alcohol, the nervous functions mentioned in the preceding chapter, and certain functions of the circulation.

The administration of alcohol as well as the performing of the tests was staggered in intervals of 7 minutes, so that each person was subjected to the tests at definite times since the commencement of alcohol ingestion. One experimenter was assigned the duty of superintending the exact adherence to schedule.

Blood samples were taken in the A_1 series at the following times from the start of the experiment: 0, 60, 90, 120, 150, 180 and 240 minutes.

Pulse rate and blood pressure were determined after each blood sample, the subject having been seated quietly for at least three minutes prior to these measurements. During this time, clinical evalutions were made concerning disturbances of speech, changes in complexion, and mood and physical sensations of the subjects. Upon examination of the circulatory functions, the finger-finger test, the swaying test and two dexterity tests were performed. For the assessing of intelligence only one test was employed, which could be quickly performed and easily varied in repetition. Duration and temporal succession of the tests are illustrated by Figure 1.

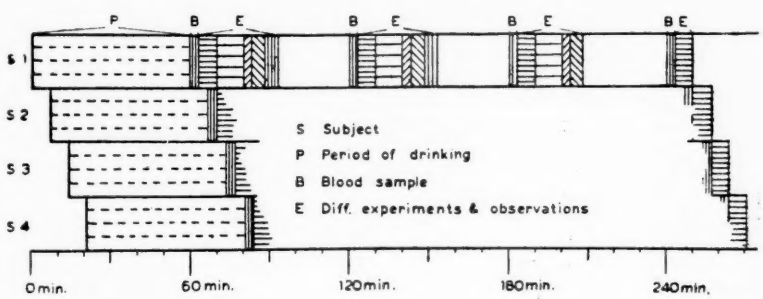

FIG. 1. *Time schedule of the experiments in the A_1 series, showing the staggering of the individual experiments.*

A_2 series. — In this series the finger-finger test was repeated, employing an improved method (GOLDBERG 1943). No blood

samples were taken during the experiments of this series in order to avoid the disturbing effect of this operation.

B series. — In this series the motility of the stomach was investigated by means of an x-ray method.

Roentgenological experiments were performed with ten subjects at the Institute of Occupational Health in a manner described in a subsequent chapter. The alcohol doses as well as the manner of administration were the same as in all other series. The experiments in this series were performed separately for each person, as opposed to the group experiments in the other series.

Blood samples were taken at 0, 60, 90, 120 and 180 minutes after the start of ingestion, and x-rays at 60, 90 and 120 minutes, immediately succeeding the taking of blood samples.

C series. — In the experiments of this series a further study of the effects of beer and of an alcohol solution of 3.2 per cent by weight on the circulatory functions and the mood is concerned, as well as a trilateral comparison together with an equivalent water quantity of the effects on physical sensations of the subject and on the compressive force of the hand. The time relation of the blood alcohol was also followed, although blood samples were taken only at 0, 60 and 120 minutes.

Cerebrospinal fluid group. — In addition, an investigation was made on three persons concerning the time relation of alcohol in the cisternal fluid; all these three persons have also participated in the experiments of the A_2 and B series. From one subject simultaneous samples were drawn from the cisterna magna by suboccipital punction and of venous blood at the times of 0, 60, 90, 120 and 180 minutes. From the other two persons samples from the cisterna magna were drawn as well, although only at 60 minutes.

The methods of investigation will be explained in more detail in appropriate places at the beginning of each experimental report.

232. THE EXPERIMENTAL SUBJECTS

The following experimental subjects, all male, took part in the experiments. Their individual ages and weights are given in Table 26 in the Appendix.

Preliminary investigation: Twelve persons.

A_1 series: Initially seventeen persons. In the case of five subjects the experiments could not be concluded for various reasons (vomiting during the experiment, failure to attend the second experiment, etc.). Hence, the group ultimately consists of twelve subjects.

A_2 series and B series: The same ten persons were used for these two experimental series.

Cerebrospinal fluid group: Three subjects, who also took part in the experiments of the A_2 and B series.

C series: Eleven persons, nine of which constitute the actual experimental group, since two subjects failed to participate in all tests. Two of the subjects had also participated in the A_2 and B series.

Altogether 48 experimental subjects have thus participated in the experiments. Twelve subjects took part in two series, three subjects in three series. In all comparisons between different kinds of beverages the same experimental subjects have been used in both component experiments.

The subjects of the preliminary and the A_1 series were volunteers from the personnel of one and the same enterprise, i.e., storage clerks and members of the sales staff. Their social conditions did not vary greatly, the experimental population being fairly homogenous even in this respect.

The consent of the family was required before the experimental subjects were accepted.

All subjects in the A_1 series were allowed to take their usual lunch at their place of work at noon, this lunch consisting of one hot dish, bread and butter, a glass of milk, and porridge.

They had all fasted for an equal length of time, 6 hours; this is considered sufficient for the evacuation of the stomach (Tuovinen 1930).

The subjects were always punctual for the appointment and it was easy, therefore, to observe a regular schedule in the experiments.

None of the experimental subjects was engaged in heavy physical work; no one complained of fatigue at the beginning of the experiments. Since a session of 4½ hours' duration is a strain on the subject, morale was boosted in the following ways:

For each evening spent on experiments in the A_1 series, the subjects were granted an extra holiday, although not the day after, and they were seen straight home by car after the sessions. This also helped in preventing family conflicts. The subjects were aware that sandwiches, milk and refreshments would be served at the end of the session. Free intercourse was allowed in the intermissions between the recording operations. The subjects were allowed to play games, throw darts, etc. Realizing that the taking of blood samples is unpleasant to many people, which may also affect the experimental results and particularly the morale, it was seen to that the samples were taken by a skilled nurse, who was very capable in the handling of patients.

Acceptance of the experimental subjects was conditional on the following considerations: Persons of remarkably excessive or deficient weight, persons with a disorder of the digestive tract, especially of a type capable of interfering with resorption, or with a history of such a disease, persons with neurological or mental disturbances or with a tendency to pathological alcohol reaction or to intemperance were not accepted.

The twelve experimental subjects of the A_1 series were all moderate users of alcohol. Their age varied from 22 to 43 years, the mean age being 32.5 years. Ten subjects were under 40 years. The weight of the subjects varied from 63 to 82 kg, the mean being 73.3 kg.

The population of the A_2 and B series consisted of ten subjects. Their age varied from 26 to 49 years, the mean age being 36.1 years, and their weight varied from 61 to 81 kg, with the mean 69.3 kg. As to occupation, the group shows the following composition: three members of the technical staff of a research insti-

tute, one photographer, one chauffeur, one journalist, three manual labourers, and one fisherman. They, too, were all moderate users of alcohol.

All the experimental subjects of the C series were undergraduates. The results of nine subjects only were considered in the final evalution; the age of these subjects varied from 20 to 32 years, the mean being 25.3 years, and their weight from 61 to 80 kg, with the mean 66.5 kg.

The age of the three subjects of the cerebrospinal fluid group varied from 30 to 49 years, and their weight from 75 to 82 kg.

A control group was used only to check the dexterity and intelligence tests. This group consisted of 18 men from a course for prison warders. With regard to age, health, and largely also to social status this group was well comparable with the A_1 group.

233. TIME OF THE EXPERIMENTAL SESSIONS

The experiments of the A_1 series were carried out on the following dates:

Brandy exp.	6.10.1952	13.10.1952	20.10.1952	30. 3.1953
Beer exp. ..	27.10.1952	17.11.1952	9. 2.1953	10.12.1953

In all series except the A_2 series each subject participated at first in the brandy and then in the beer experiment. The experiments of the A_2, B, and C series were carried out in 1955 and 1956.

Owing to practical difficulties connected with the calling together of the subjects, different time intervals occurred between sessions in the experimental groups and in the control group. The shortest and longest intervals between a brandy and a beer experiment in the A_1 series were three weeks and over eight months, respectively. The control group participated in the experiments with an interval of two weeks. Hence it was not possible to control the results of the experimental groups with the aid of the control group in the way originally planned.

All such experiments which had to be compared with each other were arranged to take place at the same hour of the day.

The state of intoxication is more natural in the evening from the standpoint of the accustomed 24-hour rhythm. The experiments of the A_1 series were thus commenced at 5 p.m. (after termination of the working day), and this was also the case

in the experiments of the A_2 series. The experiments of the B series started at 2 p.m., only one subject being examined at a time. Owing to unavoidable practical considerations, the experiments of the C series took place later in the evening, for which reason the experiments had to be discontinued at an earlier stage.

234. THE EXPERIMENTAL BEVERAGES AND THEIR DOSAGE

According to information obtained from the Central Laboratory of the Finnish State Alcohol Monopoly and from Mr. A. Rahiala, M.Sc., head of the laboratory of Sinebrychoff's Breweries, Helsinki, the main characteristics of the beverages used in the present investigation were as shown in the tables below. A more detailed discussion of the properties of these beverages will be found on page 111.

Blended brandy

Alcohol	32.6 per cent by weight
»	39.5 per cent by volume
Sugar	0.1 per cent by weight
(content of French brandy not stated)	
Specific gravity	0.96

Beer (class III)

Alcohol	3.6 per cent by weight
»	4.6 per cent by volume
Total extract	4.0 per cent by weight
CO_2	4.0 per cent by weight
Carbohydrates	~ 3.0 per cent
Proteins	~ 0.3 per cent
Specific gravity	1.01

The alcohol solutions were prepared from a solution of ethyl alcohol of 94 per cent by weight, diluted with tap water.

Tap water was also used in the experiments with water.

In the brandy and beer experiments the dosage was equivalent to 1 g of absolute alcohol per 1 kg of body weight. This dosis

was divided into six equal portions which were taken within one hour at regular intervals under control, starting at 0 minutes. The last portion was taken at 50 minutes.

In the experiments of the C series an aqueous solution of alcohol of 3.2 per cent by weight was used. Three subjects from the B series were also given an alcohol solution of 3.6 per cent by weight. These beverages, too, were administered in strict observance of the identical schedule and under supervision. The beverages were served at room temperature (18—20 C°).

In order to facilitate the determination of the appropriate individual dosage of the various beverages, a nomograph was prepared, from which the dosis could be read immediately in terms of the weight of the subject and of the beverage in question.

24. STATISTICAL ANALYSIS

In consideration of the amount of work involved in statistical calculations, the application of statistical analysis has been restricted in certain cases to the points of greatest interest with regard to the comparisons instituted in this work. Most consistently the statistical procedure has been followed in the case of the observations relating to nervous functions.

241. THE DESCRIPTION OF OBSERVATIONS

In the presentation of the basic observations, the common arithmetic mean has been computed in order to characterize the central tendency. To describe the dispersion of the material, the extreme values, i.e., the largest and the smallest observation in a series, are given. In this way the tedious calculation of the usual standard deviation estimators could be avoided; it has been shown (Noether 1955) that the difference of the extreme values, or the range, is practially equally informative in regard to dispersion as is the standard deviation.

242. COMPARISONS BETWEEN EXPERIMENTAL SERIES

For the statistical comparison, e.g., of the brandy and beer experiments, the difference of the observations in these two

experiments, d, was calculated for each experimental subject separately:

(1) $$d = x_a - x_b.$$

In this formula, x stands for individual observations, the sub-indices a and b referring to two separate experiments.

The mean difference $\bar{d}$ has then been calculated in order to express the average tendency of a difference to appear between the two experiments. The significance of the mean difference has been studied by calculating its standard error

(2) $$s_{\bar{d}} = \sqrt{\Sigma (d-\bar{d})^2 / n (n-1)}.$$

In this formula, n denotes the number of observations in each experiment. This calculation makes use of the relation

(3) $$\Sigma (d-\bar{d})^2 = \Sigma d^2 - (\Sigma d)^2 / n.$$

A statistical test of significance of the observed mean difference has now been performed by calculating the value of the test variable t as follows:

(4) $$t = d / s_{\bar{d}}.$$

The statistical significance of the different numerical values of this variable can be evaluated by consulting the appropriate statistical tables (Fisher and Yates 1953), observing that there are $n-1$ degrees of freedom when n is the number of independent differences d under investigation. The tables give the maximum probability P that a t value equal to or larger than that actually observed is due to chance only, i.e., the probability of the mean difference being due to chance only. If this probability does not exceed 0.05 (5 per cent), the observed difference is usually considered significant, although in this limit case it may still be due to chance in about one of 20 cases. In the presentation of the results of statistical tests, the standard error and the value of the test variable t have been given in the tables together with the probability P. However, this last-mentioned probability has been replaced with two dots (..) if its numerical value exceeds 0.05, in which case it is devoid of practical interest.

At the comparison of observations made at different times in one and the same experiment, the statistical procedure has been similar to that described above. The sub-indices a and b of for-

mula (1) now refer to different times as counted from the commencement of the experiment.

Finally, the increments or decrements of the observed variables in the course of time have been subjected to statistical analysis of potential differences, e.g., between the brandy experiments and the beer experiments. Again, the statistical procedure has been consistent with the foregoing description. At first, the difference between the brandy and beer experiments of any such increment or decrement has been calculated separately for each subject, whereafter the differences have been analyzed as above.

All the *t* tests are based on a statistical method which can be found in any text-book on statistics (e.g. FISHER 1950).

243. ACCOUNTING FOR THE EFFECT OF TRAINING

As some effect of training on the results can be expected to manifest itself particularly in the dexterity and intelligence tests, the matter has been investigated by means of separate experiments (p. 25, 31). On the basis of the mean results from these experiments, the following method has been applied in an attempt to eliminate the effect of training.

It is assumed that the performance improves under training at a decreasing rate, i.e., that the first few training runs are relatively more effectual than later repetitions. In many cases the achievement has been found to be at least approximately linearly related with the logarithm of the number of performances, as counted from the start of training, which is a mathematical formulation consistent with the »law of decreasing effectuality» just outlined. The following calculations are based on the assumption that the log-linear relation described constitutes a suitable mathematical model in the present case (cf. HADLEY 1950).

Let y_k be the mean result in the control test, the ordinal number of the performance being k. If the above log-linear relation is approximately valid, then

$$y_k \simeq a + b \log k, \tag{5}$$

where a and b are constants. These constants have been estimated by means of the method of least squares so that the curve represented by the right hand member of formula (5) shows the best

possible agreement with the mean results of the control tests (as to the method, see e.g. FISHER 1950). After this, values of the »ideal» learning curve

$$y_k^* = a + b \log k \tag{6}$$

have been computed for each k; these values increase uniformly with the logarithm of k. Finally, a correction coefficient

$$c_k = y_1^* / y_k^* \tag{7}$$

has been calculated for each k. The actual observations have to be multiplied by these coefficients in order to allow for the effect of training. The following correction coefficients c_k have been found:

Test	Control test performance No. corresponding to hours after commencement of the experiment							
	$k=1$	2	3	4	5	6	7	8
	in the brandy experiment				in the beer experiment			
	0	1	2	3	0	1	2	3
Santa Ana — Manual dexterity	1.00	0.94	0.90	0.88	0.86	0.85	0.84	0.83
O'Connor — Finger dexterity	1.00	0.91	0.86	0.84	0.81	0.80	0.78	0.77
Square test — Intellectual performance ..	1.00	0.77	0.68	0.62	0.59	0.56	0.54	0.53

As a test of the validity of the correction method outlined above, variance analysis has been applied in order to show the degree of agreement of the regression curve y_k^* with the averages y_k of the control tests. The following P values reveal the significance of regression, as tested by means of the variance ratio:

Santa Ana — Manual dexterity	$P = 0.005$
O'Connor — Finger dexterity	$P = 0.005$
Square test	$P = 0.025$.

Even though the dependence is not very strong in the square test, it is sufficient to validate the regression equation obtained.

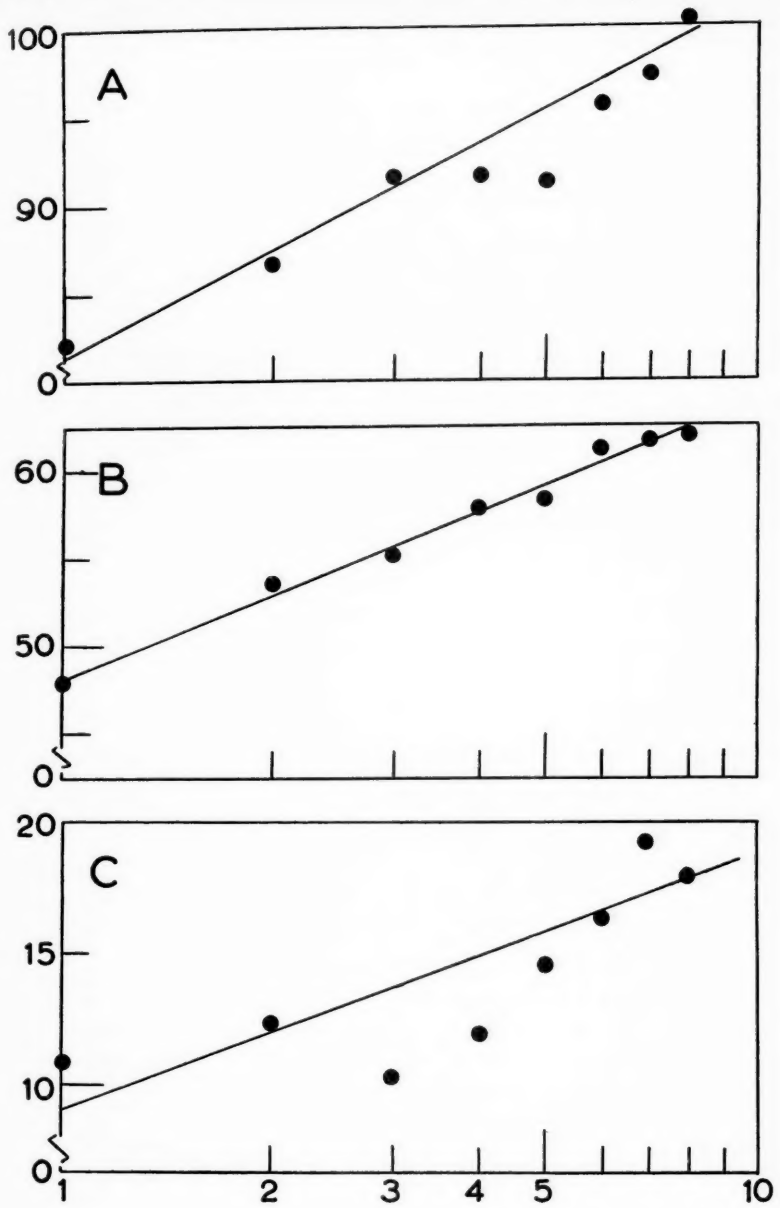

FIG. 2. *Coordination of score and number of performance in the control experiments (effect of learning), A_1 series.*

A *Manual dexterity test (Santa Ana)*
B *Finger dexterity test (O'Connor)*
C *Intellectual performance (Square test)*

In the two other tests, the regression equation seems to be in good agreement with observation (Figure 2).

The results of the three tests under consideration have been presented both as such and as corrected by the method described in the foregoing. Similar statistical tests have been performed for both results series. In the case of the corrected series, the computation of standard errors is based on a general theorem concerning the computation of variances, which theorem can be applied to the squared standard error:

$$\sigma^2(qx) = q^2\,\sigma^2(x). \tag{8}$$

Formula (8) implies that if a statistical variable x is multiplied by any constant q, the variance of the transformed variable qx equals the original variance σ^2 multiplied by the square of the constant, q^2.

244. GRAPHICAL REPRESENTATION

Curves showing the course of the averages have been plotted on semi-logarithmic paper in such a way that the scales of all different graphs are directly comparable with each other. Thus, proportionally equal increments or decrements appear equal in all graphs. In some correlation graphs, on the other hand, uniform scales have been used.

3. EXPERIMENTS AND RESULTS

31. BLOOD ALCOHOL AND RELATED OBSERVATIONS

The bulk of the present experimental material relating to the effects of the experimental beverages upon the alcohol content of the blood has been derived from the experiments of the A_1 series, but it will also be complemented in the following by observations on the alcohol content in the cerebrospinal fluid of a few subjects and by the observations relating to blood alcohol in the C series. The blood alcohol determinations made in connection with the study of the motility of the stomach (B series) are treated in Chapter 4.

311. BLOOD ALCOHOL

Method. — All blood alcohol determinations were made by Mr. A. J. A. KERÄNEN, M.Sc., in the Research Laboratories of the State Alcohol Monopoly, Helsinki. The method used was WIDMARK's micro method (1932), which is in general regarded as reliable (JUNGMICHEL 1933, SCHMIDT 1937, BJERVER, BONNICHSEN, GOLDBERG and THEORELL 1950, ALHA 1951).

In the A_1 series, in which also the neurological studies were important, as well as in the preliminary investigation series, the blood samples were drawn as capillary blood from the finger-tip. In the other series the blood samples were drawn from venous blood. In the first-mentioned case thus a better correspondence between the blood alcohol and the concentration of alcohol in the brain will have been obtained. It is well-known that during absorption the concentration of alcohol in the venous blood lags somewhat behind that in the arterial blood (HAGGARD et al. 1934, SCHMIDT 1937, ALHA 1951, NEWMAN 1947), but gradually the values come closer together and in a later phase hardly any difference is observable (SCHMIDT 1937). After about one hour the ratio of the alcohol contents of venous and arterial blood is approximately 1 (HARGER 1948). It should also be noted that the absolute blood alcohol figures as such have no decisive significance in this investigation,

as we are primarily interested in a comparison between the effects of two beverages, the same method being used in both instances.

Preliminary series. — A preliminary investigation was made on two groups on April 16th, 1952 and May 25th, 1952. Both groups consisted of six experimental subjects. In these experiments part of the subjects were given 6 bottles of beer of 3.6 per cent by weight, containing 500 ml each, and the others were given 300 ml of brandy of 32.6 per cent by weight. These quantities were divided into six portions and ingested at regular intervals within one hour. During the experiment the total amount of liquid was found to be too great, especially in the beer experiment. Many subjects vomited during the period from 60 to 240 minutes.

In addition to vomiting, many subjects had a feeling of nausea, which also may have an adverse effect upon the experimental performances.

On the strength of these observations it was decided to perform the experiments with reduced dosage and on smaller groups. Finally, the following arrangement of experiments was chosen: Altogether four groups of four subjects each were investigated in the brandy and the beer series with a dosage of 1 g of absolute alcohol per 1 kg of body weight ingested either as brandy or as beer.

The results relating to the course of the blood alcohol curve in the A_1 series are presented below. The results of the other series are presented in connection with the other experimental results obtained in each one of them.

A_1 series. — Table 27 in the Appendix shows the individual blood alcohol values at consecutive determinations in the brandy and the beer experiments.

In each instance three replicate blood samples were drawn into so-called Widmark capillaries, the determinations being made from two of these samples; the third sample was reserved to be used in case the results of the first two determinations would have differed by more than 0,05 per mil, which did not happen in one single case.

Table 1 gives the arithmetic means of the blood alcohol figures and their range as well as the average differences between the successive individual values and their range, in the brandy and beer experiments.

TABLE 1. *Blood alcohol, per mil, in the brandy and beer experiments (A_1 series)*

	Time, minutes since commencement of ingestion						
	0	60	90	120	150	180	240
	Brandy experiments						
Mean	0.06	1.24	1.24	1.09	1.00	0.93	0.80
Lowest	0.01	0.50	1.07	0.96	0.89	0.82	0.66
Highest ..	0.13	2.23	1.61	1.25	1.12	1.08	0.88
	Beer experiments						
Mean	0.04	0.87	1.04	1.08	1.03	0.96	0.85
Lowest	0.01	0.47	0.85	0.89	0.79	0.70	0.64
Highest ..	0.07	1.13	1.27	1.23	1.18	1.11	1.04
	Difference *Brandy minus beer experiments*						
Mean	0.01	0.37	0.19	0.01	—0.03	—0.02	—0.05
Lowest	—0.06	—0.31	—0.12	—0.19	—0.20	—0.16	—0.16
Highest	0.12	1.25	0.58	0.18	0.13	0.18	0.08
Mean error	0.014	0.107	0.048	0.027	0.028	0.027	0.021
t	1.0	3.5	4.0	0.4	1.1	0.8	2.2
P	..	0.01	0.01	..	..	..	0.05

It is noted that the mean value of the so-called »physiological» blood alcohol is about 0.05 per mil for the entire experimental group. This value appears somewhat high, but this may be due to the short duration of the fast (six hours) preceding the taking of the blood samples (cf. SCHMIDT 1937). This duration of the fast is, however, regarded sufficient for the evacuation of the stomach (TUOVINEN 1930). The highest initial alcohol values were 0.12 and 0.13 per mil, the alcohol abstinence of the subjects being strictly controlled.

Table 1 shows further that at 60 and 90 minutes the mean differences (brandy series minus beer series) are significantly positive. At 120, 150 and 180 minutes no significant differences can be observed. At 240 minutes the difference is again significant but negative. The statement that the beer curve is above the brandy curve at 240 minutes cannot be made with any great confidence since the negative difference, though significant ($P = 0.05$), is quite small.

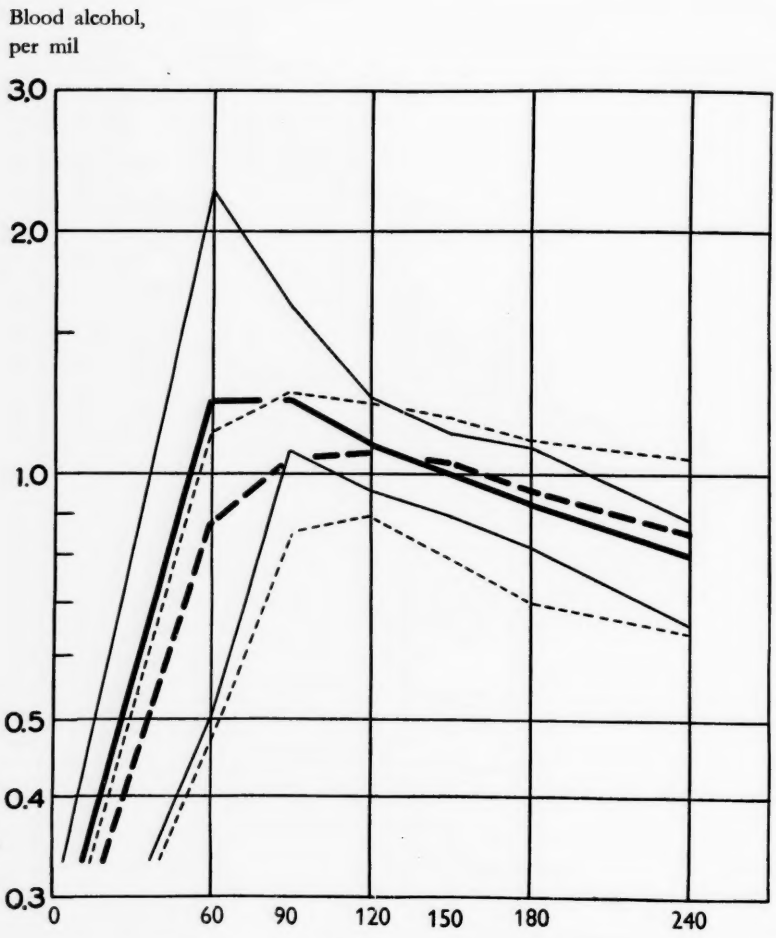

FIG. 3. *Mean values of blood alcohol in the brandy and beer experiments, A_1 series.*

Brandy experiments, mean values
» » *highest and lowest*
Beer experiments, mean values
» » *highest and lowest*

Figure 3 shows the mean blood alcohol curves from the brandy and the beer experiments in the A_1 series, together with its extreme values. It can be seen that in the brandy experiment both the mean curve and those of the extreme values rose more abruptly during the first hour than in the beer experiment. At 90 minutes

the lowest value in the brandy experiment exceeded the mean value in the beer experiment. According to the graphical representation of the mean values, the mean maximum in the brandy experiments occurs between 60 and 90 minutes, and in the beer experiments between 90 and 120 minutes, probably nearer to 120 minutes. After 120 minutes the mean curves of both series decline nearly rectilinearly, but in such a manner that the beer curve transcends to a position slightly above the brandy curve. At 60 minutes the range between the extreme values is very wide in the brandy series, which time also coincides with that of the greatest range observed in the beer series. From 90 minutes onward the range is reduced in the brandy series; during the rest of the experiment it remains within the extreme values of the beer experiments.

Table 2 shows the changes in blood alcohol at the consecutive points of time. It can be noted that during the interval from 0 to 60 minutes the mean blood alcohol in the brandy experiment has risen by about 1.19 per mil; this increase is significant. From 60 to 90 minutes no significant change can be observed in the brandy experiments; all later determinations reveal a significant decrease of the blood alcohol.

In the beer experiments, on the other hand, the following changes were observed in the average blood alcohol values:

During the interval from 0 to 60 minutes the mean blood alcohol has risen significantly (by about 0.83 per mil). Further rise occurred between 60 and 90 minutes, the average change amounting to 0.18 per mil, which was significant as well. During the interval from 90 to 120 minutes no significant change was observable. From 120 to 150 minutes and from 150 to 180 minutes the direction of the change is negative, i.e., the blood alcohol has decreased.

Table 2 also gives the differences between the changes in blood alcohol in the brandy and beer experiments (brandy series minus beer series). A greater change can be observed in the brandy experiments between 0 and 60 minutes; this difference is significant (it has an amount of 0.36 per mil) and goes to show the incipient different trend of the curves.

During the interval from 60 to 90 minutes the difference between the changes (brandy series minus the beer series) has

TABLE 2. *Changes of blood alcohol, per mil, in the brandy and beer experiments (A_1 series)*

	Time interval, minutes since commencement of ingestion					
	0—60	60—90	90—120	120—150	150—180	180—240
	Brandy experiments					
Mean	1.19	—0.00	—0.15	—0.09	—0.06	—0.13
Lowest	0.49	—0.62	—0.37	—0.17	—0.14	—0.20
Highest	2.17	0.57	—0.04	—0.02	0.00	—0.04
Mean error	0.110	—0.086	0.025	0.015	0.012	0.013
t	10.8	0.0	5.8	6.3	5.2	10.2
P	0.001	..	0.001	0.001	0.001	0.001
	Beer experiments					
Mean	0.83	0.18	0.04	—0.05	—0.07	—0.11
Lowest	0.46	—0.05	—0.08	—0.15	—0.10	—0.18
Highest	1.10	0.56	0.14	0.06	—0.02	—0.06
Mean error	0.054	0.050	0.021	0.016	0.0085	0.011
t	15.3	3.6	1.7	3.2	8.5	9.8
P	0.001	0.01	..	0.01	0.001	0.001
	Difference *Brandy minus beer experiments*					
Mean	0.36	—0.18	—0.19	—0.04	0.01	—0.02
Lowest	—0.29	—0.67	—0.51	—0.14	—0.12	—0.13
Highest	1.24	0.41	—0.05	0.03	0.08	0.07
Mean error	0.103	0.079	0.036	0.018	0.014	0.017
t	3.5	2.3	5.0	2.4	0.7	1.5
P	0.01	0.05	0.001	0.05	..	..

become negative with the value —0.18, which is statistically significant as well. Similarly during the subsequent intervals from 90 to 120 minutes and from 120 to 150 minutes the difference of the changes is negative, in the former interval significantly with the value —0.18, in the latter with the value — 0.04. All differences between the changes from 60 to 150 minutes show a more rapid decrease of the mean blood alcohol in the brandy than in the beer experiments.

The differences between the changes during the intervals from 150 to 180 minutes and from 180 to 240 minutes are not significant, and consequently no difference in the slope of the

curves can be established in the late stages of the experiments.

Peak level. — In the brandy experiments the maximum of the mean blood alcohol curve occurred at an earlier stage than in the beer experiments. No distinct peaks could be observed, but the determinations show that the difference in time is at least 30, or even 45 minutes.

The means of all the observed individual peaks (which are to be considered »pseudo-maxima»; cf. e.g. ALHA 1951) and their differences (brandy series minus beer series) are shown in Table 3. If no attention is paid to the time, the difference between the means of all individual peaks in the brandy and the beer experiments is significant, amounting to 0.25 per mil. In each case the numerical value of the observed peak caused by brandy was higher than of that caused by beer in the same subject.

TABLE 3. *Peak values of blood alcohol, per mil, in the brandy and beer experiments (A_1 series)*

	Brandy exp.	Beer exp.	Difference Brandy minus beer exp.
Mean	1.35	1.10	0.25
Lowest	1.07	0.89	0.02
Highest	2.23	1.27	1.06
Mean error	0.295	0.113	..
Stand. deviation	0.085	0.033	0.079
t	..	..	3.1
P	..	..	0.01

Figure 4 illustrates the temporal occurrence of the observed individual peaks.

A closer study of the rate of elimination would have required a greater number of blood alcohol determinations during the period of its decrease than could reasonably be made in these experiments. Therefore, it is not possible to determine with certainty whether there is any difference in the rate of elimination between these two beverages. Attention should be paid to the fact that the blood alcohol value was somewhat higher in all consecutive determinations in the beer experiments towards the

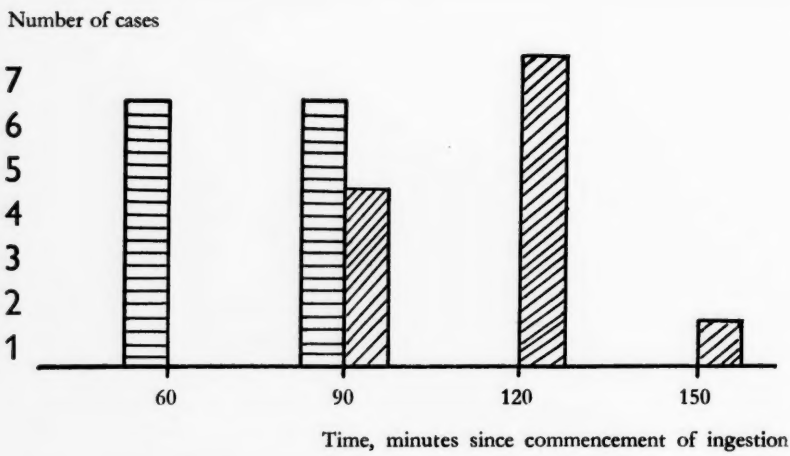

FIG. 4. *Distribution of the cases according to the time of occurrence of the highest blood alcohol value observed in the brandy and beer experiments, A_1 series.*

Peak in the brandy experiment *Peak in the beer experiment*

end of the experiment than in the brandy experiments. There is reason to suppose that in some cases the resorption of beer may still have been incomplete. These questions will be discussed later in connection with the study relating to the motility of the stomach.

Range of variation. — In the brandy experiments the distance between the extreme blood alcohol curves was considerably greater at 60 minutes than in the beer experiment: 1.73 per mil in the brandy and 0.6 per mil in the beer experiments. The same characteristic is displayed by the brandy experiments particularly with regard to certain neurological functions at 60 minutes, as will be found later. From 90 minutes up to the end of the experiment the range between the extreme values remains smaller in the brandy than in the beer experiments, as has been pointed out before.

Figure 5 shows the distribution of the subjects according to blood alcohol at 60, 90 and 120 minutes, in classes corresponding to 0.2 per mil increments of the blood alcohol. The resulting figures approximate the Gaussian distribution, and the position of the peaks at each point of time is in approximate agreement

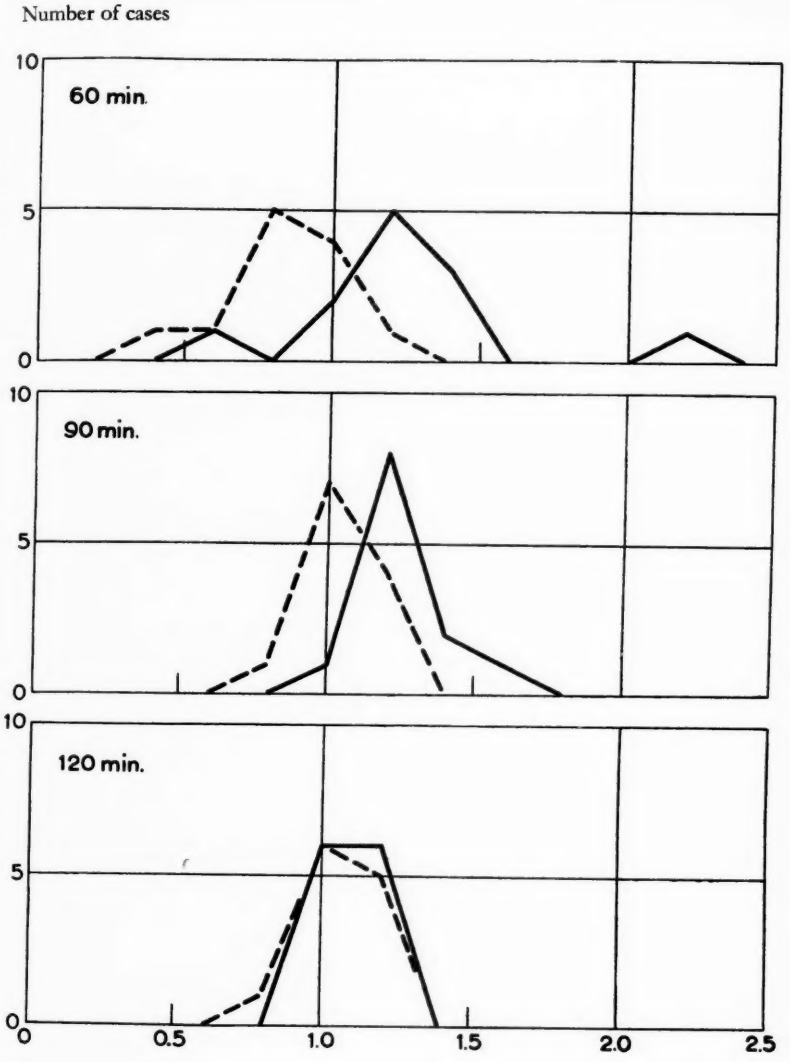

FIG. 5. *Distribution of the subjects, at 60, 90 and 120 minutes since the commencement of ingestion, according to 0.2 per mil blood alcohol intervals.*

——— *Brandy experiments*

– – – – *Beer experiments*

with the maximum of the blood alcohol in the brandy and the beer experiments. It can be observed that the brandy experiments show a higher concentration of alcohol in the blood and also a wider range between the extreme values than the beer experiments. At 90 minutes the brandy and the beer curves approach each other and the range diminishes, and at 120 minutes the differences have almost entirely disappeared.

Individual observations. — Figure 6 shows the individual blood alcohol curves. In the cases No. 1, 2, 3, 5, 7, 8, and 12, fairly regular so-called Widmark curves have been obtained. In curve No. 1 the maximum was observed at 90 minutes both

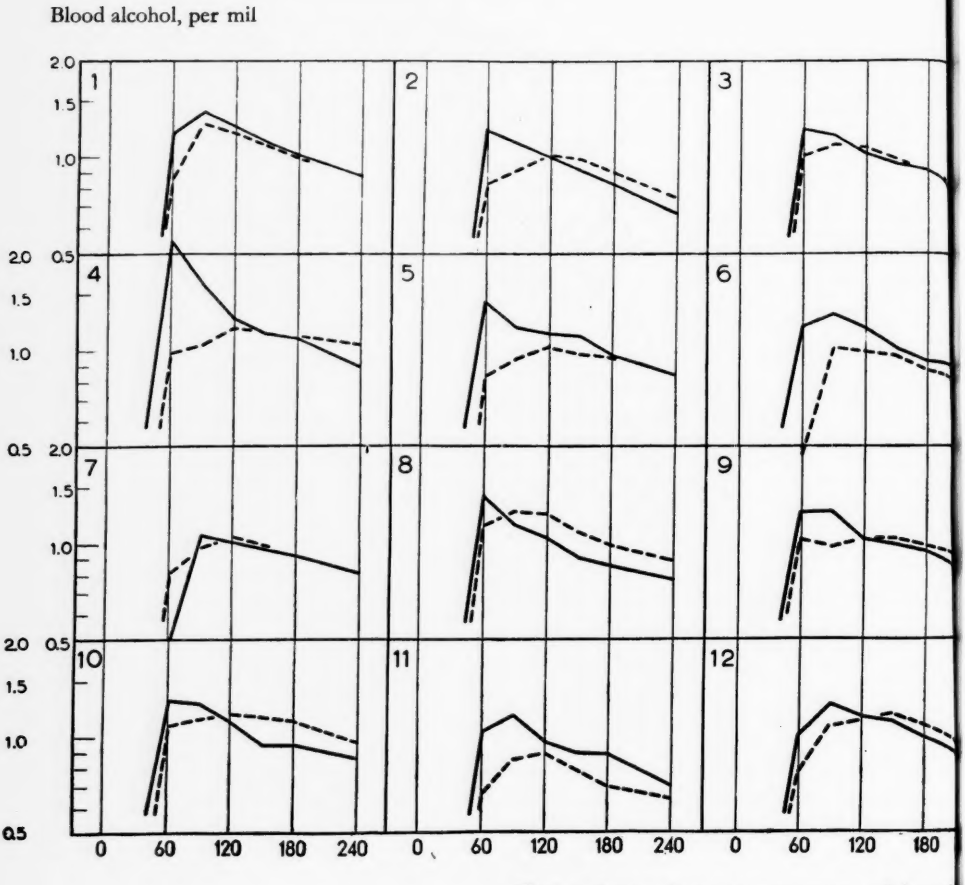

FIG. 6. *Individual blood alcohol curves of subjects 1 to 12.*

in the brandy and the beer experiment, but it appears as if the real maximum had occurred earlier in the brandy experiment. In three of these cases the descending beer curve seems to lie above the brandy curve, whereas it retains the same level in the other four cases.

Case No. 4 shows a very abrupt rise in the brandy experiment during the first hour; the curve is of the so-called »overshooting» type (HAGGARD et al. 1941). A similar curve occurred only in one other case in the A_1 series, with a subject who was excluded from the series

In case No. 4 a slight depression can be observed at 90 minutes in the beer experiment, and in case No. 9 as well. It is possible that they are symptoms of disturbances in resorption, possibly caused by delayed evacuation of the stomach.

In the cases No. 6 and 11 the beer curves have remained relatively low, which, too, may be due to slow absorption, probably attributable to similar causes as in the preceding case.

In case No. 7 the blood alcohol has exceptionally remained lower in the brandy than in the beer experiment at 60 minutes. A retarding effect on the evacuation of the stomach, and pylorospasm, may also be caused by stronger beverages (CORI, VILLIAUME and CORI 1930, GOLDBERG 1951). MAYER (1936) assumes a reaction of this kind to be caused by "intermittent resorption", presumably due to vegetative-vasomotor obstructions in absorption.

In case No. 10 a small »GRÉHANT's plateau» (see. e.g. ALHA 1951) can be seen in the brandy experiment during the interval from 150 to 180 minutes.

Synopsis. — The results from the comparisons of the blood alcohol in the brandy and beer experiments can be summarized as follows:

1. The blood alcohol rises abruptly in the brandy experiments. The mean curve seems to have reached its maximum during the interval from 60 to 90 minutes, after which it begins to fall. The changes during the interval from 0 to 60 minutes and at all times after 90 minutes are statistically significant.
2. In the beer experiments the mean curve rises more slowly and seems to have reached its maximum during the interval from 90 to 120 minutes, probably nearer to the latter time. After this it begins to fall. The changes during the intervals from 0 to 60 minutes and from 60 to 90 minutes and in all intervals after 120 minutes are statistically significant.
3. In the brandy experiments the individual »maximum» was observed to occur at 60 minutes in six cases and at 90 minutes in six cases.
4. In the beer experiments the »maximum» was observed at 90 minutes in four cases, at 120 minutes in seven cases, and at 150 minutes in one case.

5. The range, especially in the brandy experiments, is very wide at 60 minutes, but it grows markedly narrower after 90 minutes. Later on it remains nearly unchanged. In the beer experiments the range is similarly rather wide at 60 minutes, although markedly narrower than in the brandy experiments. After 90 minutes the range is narrower in the brandy experiments than in the beer experiments during the whole period of decline, and it is situated within the latter.
6. The following significant differences between the brandy and the beer experiments were observed:
   a) The rate of increase is significantly greater in the brandy experiments. (The difference in the changes of the experimental results during the interval from 0 to 60 minutes is significant.)
   b) The figures show a different trend during the interval from 90 to 120 minutes, the brandy curve declining while the beer curve was still rising. In the brandy experiments the blood alcohol begins to disappear earlier than in the beer experiments.
   c) The mean differences of the blood alcohol at 60 and 90 minutes show a value of 0.37 per mil and 0.19 per mil, respectively. The blood alcohol has thus risen to a higher value during the first hour and a half in the brandy experiments than in the beer experiments.
7. After the mean curve had reached its maximum in the beer experiments at 120 minutes, no significant differences could be observed any more. At later times the beer curve has crossed over the brandy curve, but this was not significant except at 240 minutes, and it should further be noted that the difference is quite small.

312. ALCOHOL CONTENT OF THE CEREBROSPINAL FLUID

The appearance of alcohol in the cisternal liquor has been investigated, among others, by Nicloux (1900), Schumm and Fleischmann (1913), Abramson and Linde (1930), Matossi (1931) Mehrtens and Newman (1933), Harger, Hulpieu and Lamb (1937), Goldberg (1937 a, b), Schmidt (1937), Riklin (1938), and Gabriel (1938).

According to these investigations, the alcohol content of the cisternal fluid lags behind the blood alcohol during the increase of the latter. However, the curves close together rapidly, crossing later, after which the alcohol curve of the cisternal fluid remains above the blood alcohol curve. The alcohol concentration in the lumbar fluid surpasses the blood alcohol curve considerably later.

During the descent of the blood alcohol curve the alcohol concentration in the cisternal fluid remains about 20 per cent higher than the blood alcohol (RIKLIN), both curves descending in parallel with each other.

In the present investigation the experimental group was very small, and it is not possible to make any generalizations on the basis of these results, which are merely complementary to the results of comparison relating to blood alcohol in the brandy and beer experiments, in possible corroboration of the latter.

The group comprised three subjects altogether, five suboccipital punctures being performed on one of them (person L.) in the brandy as well as in the beer experiment at the times 0, 60, 90, 120, and 180 minutes. The two other subjects (persons K. and M.) were punctured suboccipitally at 60 minutes only in both series. A blood sample was taken from the cubital vein of each subject at the same time point (about 1—2 minutes later).

TABLE 4. *Simultaneously observed alcohol contents in the blood and in the cerebrospinal (cisternal) fluid of three experimental subjects*

Subject	Experiment	Time, minutes since commencement of ingestion									
		0		60		90		120		180	
		B	C	B	C	B	C	B	C	B	C
L	Brandy	0.02	0.03	1.43	1.46	1.23	1.56	1.06	1.38	0.93	1.17
	Beer	0.02	0.03	0.54	0.61	0.87	0.97	1.00	1.13	1.03	1.27
M	Brandy	0.02		1.52	1.58	1.37					
	Beer	0.05		1.12	1.19	1.34					
K	Brandy	0.03		1.42	1.49	1.32					
	Beer	0.03		0.70	0.86	0.60					

B = blood alcohol, per mil.

C = alcohol content of the cerebrospinal (cisternal) fluid, per mil.

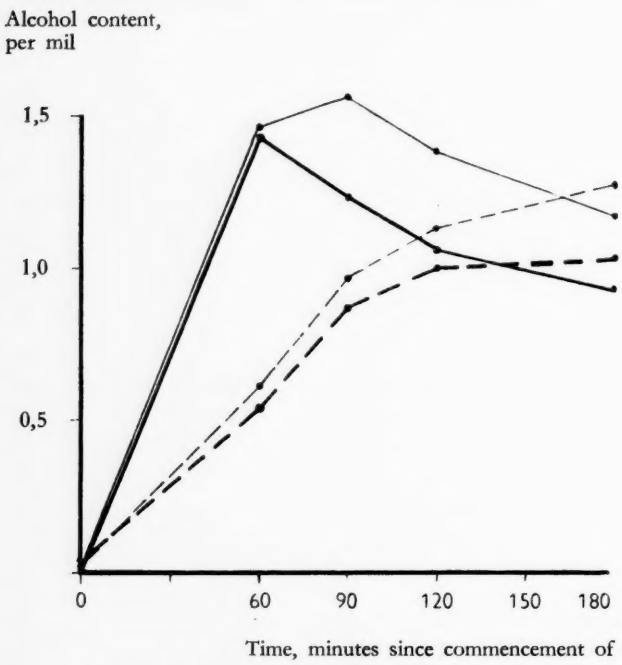

FIG. 7. *Blood alcohol and alcohol content of the cerebrospinal (cisternal) fluid of subject L. in the brandy and beer experiments.*

——— *Brandy experiment; blood alcohol*
——— » » *alcohol content of the cisternal fluid*
– – – – *Beer experiments; blood alcohol*
– · – · – » » *alcohol content of the cisternal fluid*

The alcohol contents observed in the blood and in the cerebrospinal fluid of the subjects are given in Table 4. Figure 7 shows the corresponding curves of the first-mentioned subject (person L.) in the brandy and beer experiments, the correlation graph in Figure 8 representing the relation between the two alcohol contents of all three subjects.

Person K. vomited at about 50 minutes in the beer experiment, which obviously has caused his relatively low alcohol values at 60 minutes.

It can be noted that the alcohol content of the cerebrospinal fluid is somewhat higher than the blood alcohol at all points of time, this tendency becoming transiently more marked in the latter part of the experiment.

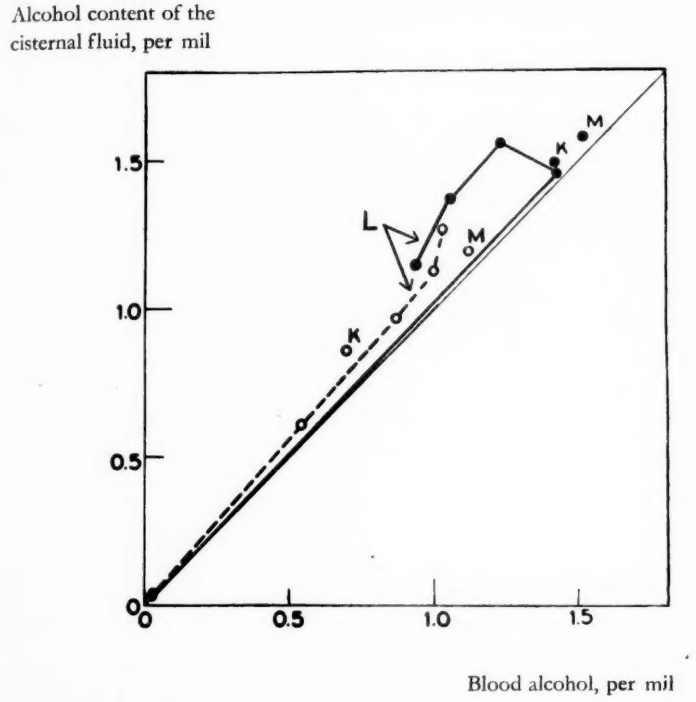

FIG. 8. *Correlation between blood alcohol and alcohol content of the cisternal fluid in the brandy and beer experiments (subjects L, M and K).*
● *Brandy experiments* ○ *Beer experiments*

Comparison of the brandy and beer experiments reveals that the results agree with the observations relating to blood alcohol in the A_1 series presented in the foregoing, as was indeed to be expected, i.e., also the alcohol content of the cerebrospinal fluid in the beer experiments lagged behind that in the brandy experiments in conformity with the behaviour of the respective blood alcohol figures.

313. BLOOD ALCOHOL IN THE C SERIES

In the experiments of the C series (nine experimental subjects, see p. 22), the blood alcohol was determined from samples taken from the cubital vein at 0, 60 and 120 minutes, both in the beer and the alcohol solution experiments. The same alcohol dosage

(1 g per kg of body weight) was employed in the beer experiments as in the other series, and its administration was arranged in the same way. Alcohol solution of 3.2 per cent by weight was given in equivalent quantities by volume; the total alcohol dosis in the alcohol solution experiments was thus 10 per cent less than in the beer experiments. This was done intentionally in an attempt to produce blood alcohol curves of essentially the same level in both cases.

Table 5 shows the mean blood alcohol figures at different times during the experiments, together with their ranges of variation. It is seen that at 60 minutes the alcohol solution has produced a slightly higher mean blood alcohol than beer, but the difference is not statistically significant. At 120 minutes, again, the mean figure is somewhat higher in the beer experiments than in the alcohol experiments, the difference being nonsignificant in this case as well. It can thus be stated that no difference in the

TABLE 5. *Blood alcohol, per mil, in the alcohol solution and beer experiments (C series)*

	Time, minutes since commencement of ingestion		
	0	60	120
	Alcohol solution experiments		
Mean	0.06	0.77	0.99
Lowest	0.03	0.62	0.82
Highest	0.07	0.87	1.25
	Beer experiments		
Mean	0.04	0.68	1.09
Lowest	0.02	0.37	0.79
Highest	0.07	0.90	1.35
	Difference *Alcohol solution minus beer experiments*		
Mean	0.02	0.06	—0.11
Lowest	—0.04	—0.04	—0.35
Highest	0.05	0.48	0.32
Mean error	0.010	0.055	0.077
t	1.7	1.2	1.5
P	..	..	..

height of blood alcohol ensued in spite of the difference in concentration between the beverages and of the different total alcohol quantities ingested.

32. CIRCULATION

In order to obtain a comparison between the possible effects of both experimental beverages on circulation, the pulse rate, blood pressure, and the colour of face were determined in the A_1 series after the subjects had been sitting quietly for three minutes. During these experiments the subjects were not in a »basal» state from the point of view of circulation, for which reason the observations cannot be generalized. Even so, comparison of the observations seems to be justified to a certain extent since the external conditions at least were similar in both series.

321. A_1 SERIES

Pulse rate. — The pulse was counted by palpation from the radial artery during 30 seconds.

Table 6 shows the mean values of pulse rate at various times in both series as well as their ranges. The averages of the differences (brandy series minus beer series) are not significant at any time. In both series only the increase of the pulse rate from 60 to 120 minutes is significant ($+4.5$; $P = 0.02$ and $+6.5$; $P = 0.01$ in the brandy and beer experiments, respectively), but the difference between these changes is not significant.

In both series a slight significant acceleration of the pulse rate could thus be established between 60 and 120 minutes, after which the slightly increased rate persisted.

During the ingestion of the beverage, from 0 to 60 minutes, the subjects were seated quietly at a table, but subsequently free intercourse was allowed; this may have had an accelerating effect upon the pulse rate during the interval from 60 to 120 minutes.

Figure 9 (p. 52) shows the mean curves for the pulse rate in the brandy and beer experiments.

The changes in pulse rate are thus rather slight, and no significant differences are demonstrable between the brandy and the beer series.

TABLE 6. *Pulse rate, systoles per minute, in the brandy and beer experiments (A_1 series)*

	Time, minutes since commencement of ingestion				
	0	60	120	180	240
	Brandy experiments				
Mean	77.3	78.8	83.3	82.0	81.0
Lowest	68	64	72	72	64
Highest	92	104	104	104	104
	Beer experiments				
Mean	78.9	75.2	81.7	80.7	80.7
Lowest	68	64	64	72	64
Highest	88	82	94	92	106

TABLE 7. *Systolic and diastolic blood pressure, mm Hg, in the brandy and beer experiments (A_1 series)*

	Time, minutes since commencement of ingestion				
	0	60	120	180	240
	Systolic pressure, brandy experiments				
Mean	131.7	131.2	130.4	129.2	127.1
Lowest	110	110	110	105	110
Highest	150	160	160	155	150
	Systolic pressure, beer experiments				
Mean	130.0	132.5	123.3	121.7	121.2
Lowest	110	115	105	110	115
Highest	170	165	145	145	145
	Diastolic pressure, brandy experiments				
Mean	80.8	84.2	83.3	83.3	82.5
Lowest ...	70	65	65	65	70
Highest ...	90	95	95	95	95
	Diastolic pressure, beer experiments				
Mean	81.7	87.9	85.4	82.5	81.2
Lowest ...	70	80	70	75	75
Highest ...	95	100	100	95	90

Blood Pressure. — The blood pressure was determined with a mercury manometer by auscultation of the cubital fossa, the readings being taken with an accuracy of 5 mmHg.

Table 7 shows the mean values and ranges of the systolic and diastolic pressure in the brandy and beer experiments. At 180 minutes and 240 minutes the means of the differences (brandy series minus beer series) become significant in the case of the systolic pressure, the mean of the differences being 7.5 mmHg ($P = 0.01$) at 180 minutes and 5.8 mmHg ($P = 0.05$) at 240 minutes. In the diastolic pressure no significant differences can be established.

In the case of the pulse pressure, significant mean differences occur at 120, 180, and 240 minutes, i.e., 9.2 mmHg ($P = 0.01$) at 120 minutes, 6.7 mmHg ($P = 0.05$) at 180 minutes, and 4.6 mmHg ($P = 0.05$) at 240 minutes.

Calculation of the changes reveals a significant change in systolic pressure in the beer series only, i.e., a decrease by 9.2 mmHg ($P = 0.01$) during the interval between 60 and 120 minutes.

Similarly, the diastolic pressure shows a significant change only in the beer experiments between 0 and 60 minutes, namely, an increase by 6.2 mmHg ($P = 0.01$).

The changes in pulse pressure are significant only in the beer experiments between 0 to 60 minutes and 60 and 120 minutes, consisting of a mean decrease by 3.7 mmHg ($P = 0.05$) and 6.7 mmHg ($P = 0.01$), respectively.

The difference, as between the brandy and the beer series, of the changes is significant only in the case of systolic pressure (8.3 mmHg) and pulse pressure (6.7 mmHg) and of the interval from 60 to 120 minutes ($P = 0.01$ in both cases).

Figure 9 shows the mean curves relating to systolic, diastolic and pulse pressure in the brandy and the beer experiments.

The results of the studies relating to pulse rate and blood pressure in the A_1 series can thus be summarized as follows:

The changes in pulse rate are quite small in either series. A slight acceleration of pulse between 60 and 120 minutes is observable in the brandy as well as the beer experiments. No significant difference could be observed between the two series.

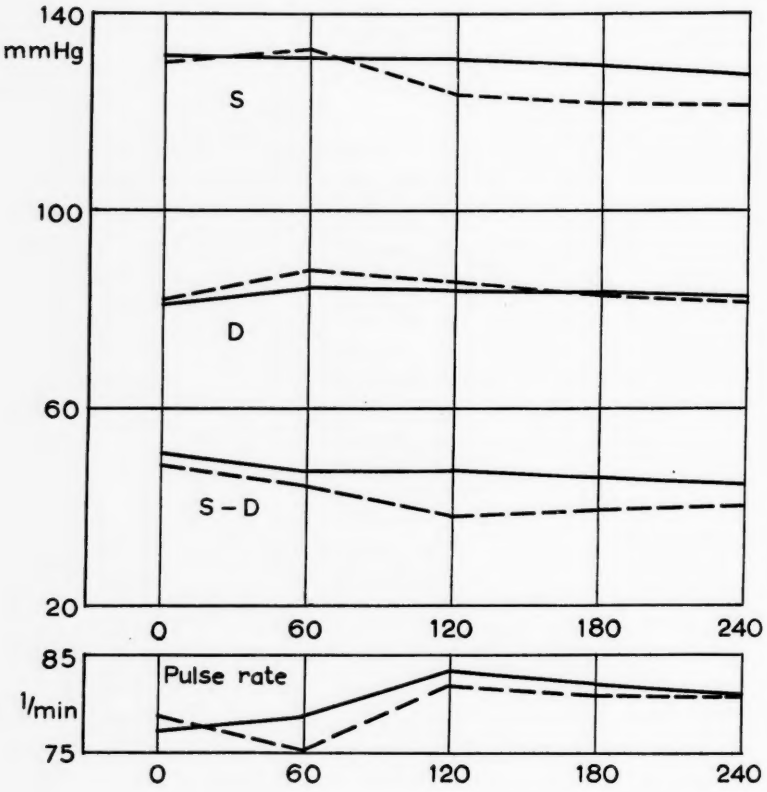

FIG. 9. *Blood pressure and pulse rate (mean values) in the brandy and beer experiments, A_1 series.*

S *Systolic pressure*
D *Diastolic pressure*
S—D *Pulse pressure*

——— *Brandy experiments*
– – – – *Beer experiments*

A fairly slight significant decrease of systolic pressure (between 60 and 120 minutes) and pulse pressure (between 0 and 60 and between 60 and 120 minutes) was observed in the beer series; insignificant indications of such a change were present in the brandy series at a late stage of the experiment. The lowest pulse pressure in the beer series was obtained at 120 minutes.

Colour of the face. — As a detail reflecting the circulation in the skin, the complexion of the face was observed with the »clinical eye» in the present investigation. Some earlier investigators have done the same in connection with their investigations of the inebriated state (ALHA 1951).

The findings are that in the brandy experiments near the peak ot the blood alcohol curve, i.e., at 60 minutes, four subjects were considered to show normal colour of face, the other four subjects being markedly flushed. At peak blood alcohol in the beer experiment, i.e., at 120 minutes, the colour of face was considered normal in six subjects, whereas ten subjects were slightly flushed one hour earlier (at 60 minutes). At 180 minutes, when the blood alcohol still was about 0.95 per mil, only in four subjects of the brandy series and in two of the beer series some reddening of the face was observable, whereas the colour was normal in the others.

However, this method is summary and unreliable in a degree precluding any recording of differences.

322. C SERIES

In the comparison between beer and an alcohol solution of 3.2 per cent by weight in the experiments of the C series (nine subjects; p. 22, 47) no significant differences were found between the effects of the beverages.

The pulse rate, recorded at 0, 10, 20, 30, 60, 90, 120 and 150 minutes, and in the beer experiment also at 180 minutes, shows the following mean values:

Time, minutes	*0*	*10*	*20*	*30*	*60*	*90*	*120*	*150*	*180*
Beer	87.0	85.9	85.1	84.8	83.2	81.4	82.8	82.8	83.8
Alcohol solution	84.8	81.3	79.6	79.6	79.2	79.3	79.3	79.1	

In both experimental series a slight reduction in pulse rate occurred, as compared with the initial values, but the differences between the experiments are not significant.

The plans were to record the blood pressure at the same times, but it was found to be impossible to follow the time-table with sufficient accuracy in regard to the observations at 10, 20 and 30 minutes, for which reason these values are left out of consideration. The mean values relating to 0, 60, 90, 120, 150 and 180 minutes, in mmHg, can be seen from the following compilation:

Time, minutes		*0*	*60*	*90*	*120*	*150*	*180*
Beer	syst.	129.0	126.0	122.0	116.5	115.0	118.0
	diast.	78.5	84.0	83.0	81.5	79.5	81.0
Alcohol	syst.	131.7	130.0	128.3	125.0	127.0	
solution	diast.	80.0	89.4	87.8	82.8	84.4	

Both in the beer and the alcohol solution experiment the decrease of systolic pressure and increase of diastolic pressure resulted in a reduction of pulse pressure. The mean change of pulse pressure was, for instance, during the interval from 0 to 120 minutes (when the pulse pressure in the beer experiments of the A_1 series was at its lowest) — 15.5 mmHg ($P = 0.01$) and —9.5 mmHg ($P = 0.05$) in the beer and alcohol solution experiments, respectively. However, no significant differences exist between the experimental series in regard to systolic, diastolic or pulse pressure.

Since no significant differences were observed between the effects of beer and of the alcohol solution, it is possible that the effect of beer, even such as it has been evident in the A_1 series in comparison with brandy, may be based on the properties of beer as a dilute alcohol solution.

It should also be noted that the experimental subjects have not been in the so-called basal state in the tests, for which reason the observations cannot be generalized. For instance, the possible settling of circulation from the »in motion» state to the »at rest» state, might also have a reducing effect upon pulse rate and blood pressure.

33. METRIC OBSERVATIONS ON NERVOUS FUNCTIONS

One of the main objects of alcohol investigation has always been the determination of the effects of alcohol on nervous and psychic functions. A considerable difficulty in the mutual comparison of experimental results arises from the fact that the object of study has mostly been some complex combination of functions, for which reason it is frequently difficult to decide which nervous function primarily constitutes the subject of each particular experiment.

Repeatedly, for instance, in the case of psychic functions, the object of study has been defined on a purely intuitive basis, and it has not been ascertained which component functions have principally been responsible for the experimental results.

In numerous investigations the recording of the results has been based on an arbitrarily chosen evaluation scale (driving tests), and consequently the generalization of such results may be questionable.

Already in earlier investigations attempts have been made to minimize the influence upon the results of such essential factors as learning and fatigue, etc. (e.g. KRAEPELIN 1924, GRAF 1928, 1930). However, particularly as regards psychometric methods of investigation, factorized tests have come into use only in the later times. Their application has made it possible to direct the attention more objectively towards certain nervous functions. It is important, particularly at a comparison between the experimental results of different investigators, to know the factor composition of the method of scoring and its correlation with other factorized testing methods involved in the comparison before any generalizations can be made.

Most earlier investigations lack statistical significance, and it is difficult to establish to what extent random factors may have affected the obtained results. The lack of statistical significance is mostly due to the small experimental populations.

331. NERVOUS FUNCTIONS RECORDED IN EARLIER INVESTIGATIONS

It has been known of old that neuromuscular coordination is a function easily disturbed under the influence of alcohol. Numerous investigators have therefore paid attention to the recording of such disturbances (ALBER 1902, DODGE and BENEDICT 1915, MILES 1918, 1924, GYLLENSWÄRD 1918, VERNON 1919, TÖTTERMAN 1920, HAMMARSTEN and LILJESTRAND 1922, TIGERSTEDT, VARTIA, LOVESON and KORHONEN 1924, GYLYS 1927, TUOVINEN 1927, GRAF 1928, 1930, 1933, HYMAN 1938, ELBEL 1937, NEWMAN and FLETCHER 1940, EGGLETON 1941, NEWMAN and ABRAMSON 1942, GOLDBERG 1943, 1948, 1951, NEWMAN 1949, BJERVER and GOLDBERG 1950, ALHA 1951, BSCHOR 1951, CARPENTER and MACLEOD 1952, MACLEOD 1953, etc.). The methodology has varied from simple mechanical recording (ALBER, GYLLENSWÄRD, VERNON, TUOVINEN, ELBEL, etc.) to more complicated mechanisms (MILES, GRAF, NEWMAN et al., EGGLETON, etc.)

The importance of nystagmus as an adequate criterion of intoxication with alcohol has been stressed by GOLDBERG and STÖRTEBECKER (1941), MEYER ZUM GOTTESBERGE (1943) and PLENKERS (1943). GOLDBERG and STÖRTEBECKER have studied the relations between postural reflexes and intoxication with alcohol.

An advanced recording method has been developed by GOLDBERG (1943, 1951) in his experiments, in which recordings were made, in addition to quantitative clinical tests (Romberg test, finger-finger test, etc.), with the aid of the flicker fusion method and the quantitative cornea reflex method.[1])

The problems connected with the acute psychic effects of alcohol have already been discussed briefly in the foregoing. Variables which have been employed to this end are, among others, auditive and visual reaction time, the ability to perform simple computations, the rating often being based on the time required, and the ability of learning, comprehension and concentration, various functions of memory (e.g. KÜRZ and KRAEPELIN 1901, RÜDIN 1904, KRAEPELIN 1924, GYLYS 1927, GRAF 1928, 1930, GOLDBERG 1943, 1951, etc.)

The methodological problems of psychological alcohol investigation have been elucidated by JELLINEK and MCFARLAND (1940) in a comprehensive survey of earlier clinical investigations, and by TAKALA (1953, 1954, 1957).

332. STATIC ATAXIA. SWAYING

Method. — Sensomotor ataxia and disturbed control of posture are classical symptoms of intoxication with alcohol. These have repeatedly been the object of study, and ROMBERG's (1846) test has become a cardinal criterion also in the clinical diagnosis of inebriety.

Swaying has been studied quantitatively, among others, by MILES (1922, 1924) and GOLDBERG (1943, 1951). In his tests, GOLDBERG used a highly developed experimental method: The

[1]) In a lecture given in Helsinki (1956), GOLDBERG reported further developments of the quantitative recording of the symptoms of intoxication, consisting of its supplementation with, e.g., electronystagmometric examination, electromyographic recording of the muscular action currents in the muscles of the lower extremities during swaying, etc.

swaying was recorded by photographing from above a source of light attached to the shoulders of the subject. The resulting image was planimetrated and the value thus obtained served as an index of swaying. Howerer, the experimental procedure as such is open to the following criticism:

1. Owing to the blurred contour of the photographic record the accurate determination of its area meets with difficulties.
2. According to this procedure the shape of the diagram will be conclusive rather than the swaying amplitude. As a rule, these two correlate well, but cases occur where considerable swaying takes place mainly in one plane only so that the area of the image is small in spite of all. It seems reasonable to regard the amplitude of swaying as the most important measure of this disturbance.
3. A recording time of 15 seconds appears too short, inasmuch as the subject may be able momentarily to pull himself together (ANDRESEN 1938, LILJESTRAND 1940, GOLDBERG 1943, ALHA 1951).

Instead of the ordinary Romberg test, its variation used also by GOLDBERG (1943), the »modified Romberg test», was employed in the present investigation. In this the subject stands with his feet placed one behind the other, with abducted and extended upper extremities. This modified posture produces a greater range of variation and prevents the subjects from momentarily pulling themselves together. Furthermore, each recording had a duration of 30 seconds instead of 15 seconds as in GOLDBERG's experiments.

The recording was achieved mechanically as in the so-called body sway test in personality studies (cf. e.g. EYSENCK 1947). Two strings were attached to neck and waist of the subject and conducted at right angles to pulleys and thence to two kymograph styli. The swaying was thus recorded separately in two dimensions, i.e., in the lateral plane and in the axial plane. The tracings were transferred onto millimetre paper from the kymograph cylinder and the motion during consecutive one-second intervals was read from this record. The mean of these 30 readings, in mm per second, furnishes a certain measure of the swaying. In order to combine the effects in the axial and lateral planes, the root square sum of the means found for either direction was computed.

Results. — Swaying was studied five minutes after the corresponding blood alcohol determination had been performed. The test was performed at 0, 60, 120, 180 and 240 minutes.

The mean results and the range found for each subject at consecutive times in the brandy and the beer experiments are shown in Table 8 (individual values in Table 28 in the Appendix).

TABLE 8. *Swaying, mm/sec, recorded in the brandy and beer experiments (A_1 series).*

	Time, minutes since commencement of ingestion				
	0	60	120	180	240
	Brandy experiments				
Mean	9.2	21.2	16.4	13.3	10.4
Lowest	6.4	7.2	7.8	7.2	7.2
Highest	11.2	49.5	42.2	31.1	17.5
	Beer experiments				
Mean	8.3	9.4	11.4	8.9	7.8
Lowest	4.2	5.0	6.4	5.7	5.0
Highest	18.3	13.6	20.0	12.2	12.5
	Difference *Brandy minus beer experiments*				
Mean	0.9	11.8	5.0	4.4	2.6
Lowest	—8.0	0.2	—10.0	0.0	—3.6
Highest	5.6	42.3	27.8	18.9	8.1
Mean error ..	1.04	3.63	2.80	1.55	0.87
t	0.8	3.3	1.8	2.8	2.9
P	..	0.01	..	0.02	0.02

Table 8 also shows the mean differences in the results (brandy series minus beer series) and Table 9 the changes during different intervals, separately for both series, and the mean differences of these changes (brandy series minus beer series).

The results reveal the following:

The initial values in the brandy and the beer experiments did not differ significantly. Hence it may be concluded that learning played hardly any part in these tests and that the values are mutually comparable as such.

In the brandy experiments the swaying increased significantly

TABLE 9. *Change of swaying, mm/sec, in the brandy and beer experiments (A_1 series)*

	Time interval, minutes since commencement of ingestion			
	0—60	60—120	120—180	180—240
	Brandy experiments			
Mean	12.1	—4.8	—3.1	—2.9
Lowest	—2.2	—33.5	—11.1	—18.6
Highest	41.0	6.8	5.2	3.1
Mean error	3.77	3.01	1.77	1.80
t	3.20	1.60	1.75	1.63
P	0.01	..	..	..
	Beer experiments			
Mean	1.1	2.0	—2.5	—1.1
Lowest	—8.0	—2.1	—10.0	—4.1
Highest	7.2	12.8	1.4	1.1
Mean error	1.17	1.42	0.99	0.44
t	0.92	1.42	2.51	2.55
P	..	..	0.05	0.05
	Difference Brandy minus beer experiments			
Mean	11.0	—6.8	—0.6	—1.8
Lowest	—2.1	—38.8	—8.9	—17.0
Highest	38.8	8.9	10.0	3.7
Mean error	3.48	3.39	1.95	1.67
t	3.2	2.0	0.3	1.1
P	0.01	..	..	..

during the interval from 0 to 60 minutes. Subsequently there was a steady decrease, which is significant in the intervals from 60 to 180 and 60 to 240 minutes. At 240 minutes the swaying had almost reverted to normal.

In the beer experiments, on the other hand, the change was quite slight. Only at 120 minutes was there an increase in the extent of swaying, but even at this point of time the swaying value does not differ significantly from the initial value at 0 minutes. After this, the swaying decreased. At the final stage of the experiment the swaying had returned to its initial level.

Comparison between the two series shows that the swaying was more marked in the brandy series throughout the experiments. The difference is significant at several times; it was at its greatest

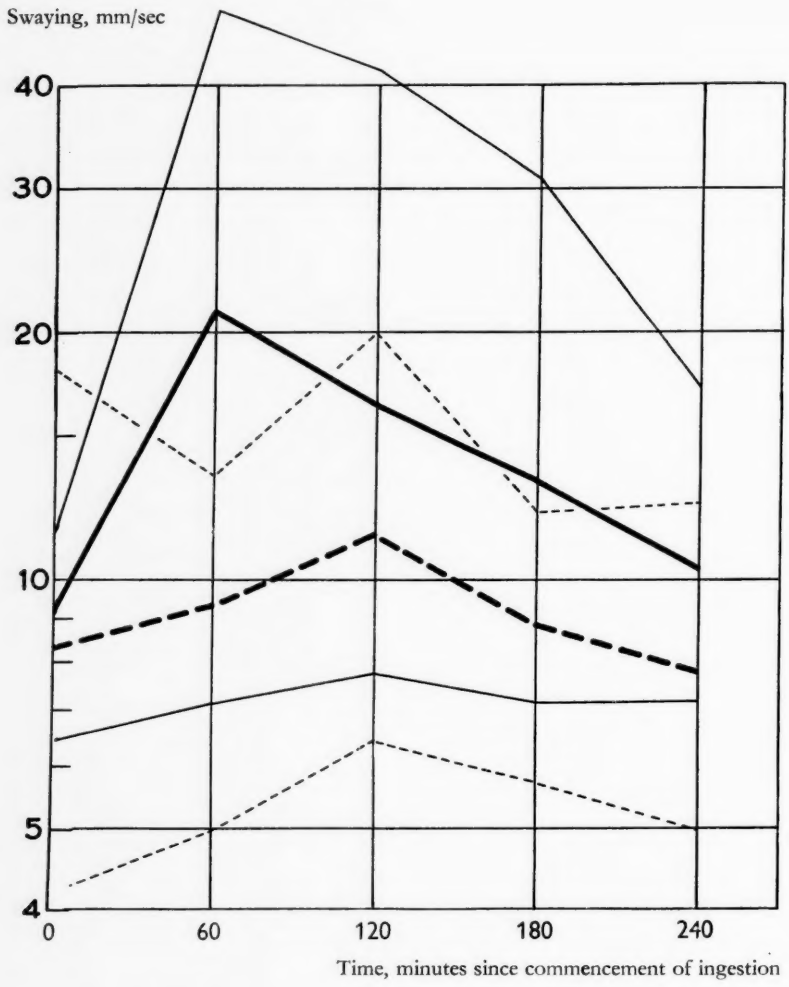

FIG. 10. *Swaying in the brandy and beer experiments, A_1 series.*

——— *Brandy experiments, mean values*
. . . . . » » *highest and lowest*
– – – – *Beer experiments, mean values*
– . – . – » » *highest and lowest*

at 60 minutes and the difference of the changes from 0 to 60 minutes is significant (Table 9).

The mean curves relating to the brandy and the beer series, together with their ranges of variation are shown in Figure 10. In the brandy series the range increased strongly as early as at 60 minutes, as did also the blood alcohol in the A_1 series. Towards the end of the experiment the range reverted to its initial magnitude. In the beer experiments, on the other hand, the range did not increase.

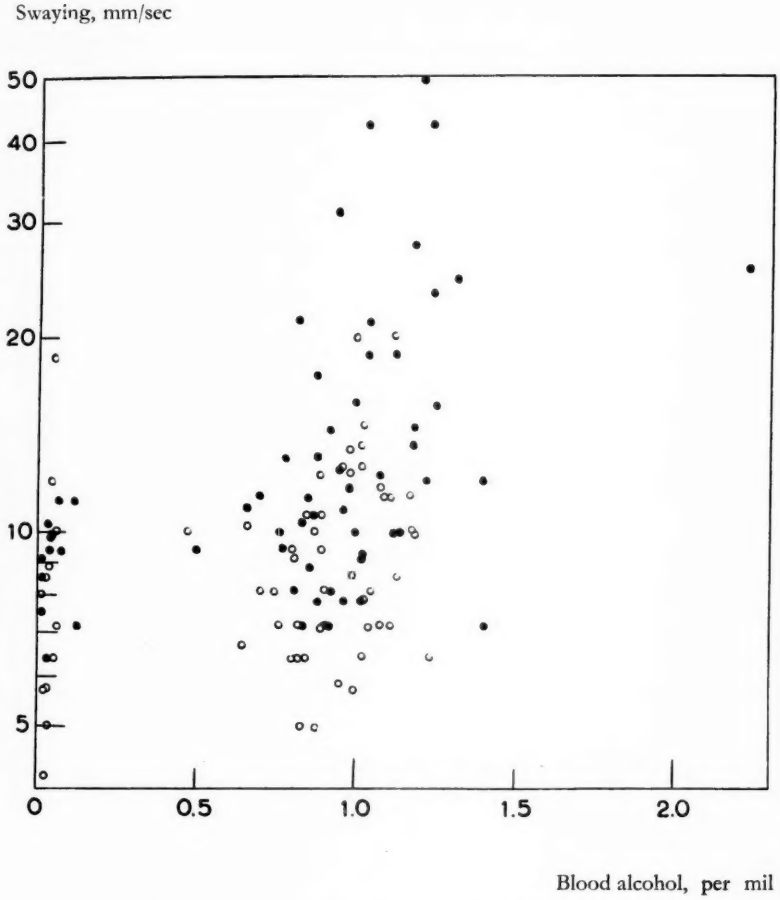

FIG. 11. *Correlation between the individual swaying values and blood alcohol, A_1 series.* ● *Brandy experiments* ○ *Beer experiments*

A scrutiny of the individual values shows that the increase of range in the brandy series is due to a few extreme values. One of the subjects displayed at 60 minutes a swaying nearly five times that of 0 minutes, whereas in another the performance of the test had even somewhat improved from its initial value. Nonetheless, both persons showed a performance in the initial test very nearly in agreement with the mean value of the entire group. Hence it might be assumed that the increase in range of the swaying values was due to an increase in that of the blood alcohol values, but there is no distinct correlation. With regard to the blood alcohol the above-mentioned extreme cases are about average for the group at the corresponding points of time. No obvious correlation can be seen between the individual blood alcohol figures and the extent of swaying (Figure 11).

Synopsis. — As a synopsis of the studies relating to swaying, it can be said that brandy caused a stronger effect of static ataxia than beer throughout the duration of the tests, the highest amount of swaying occurring in the brandy series at 60 minutes. In the beer experiments the increase of swaying was not significantly different from the value at 0 minutes even at 120 minutes when maximum swaying was observed. The difference between the brandy and beer experiments was significant at all times except at the initial determination and at 120 minutes. The increase in range of the value relating to swaying was particularly marked in the brandy seriesat 60 minutes.

It was concluded above from the initial values at 0 minutes that probably no effect of learning has occurred between the experimental sessions. However, it is conceivable, of course, that some improvement of the results could have been produced by this agent, which would have affected the later course of the experiment. This possibility does not seem very likely since a comparatively simple functional performance is concerned and since, the subjects being moderate users of alcohol, no one of them can have found himself in an unprecedented situation with regard to inebriation even at the time of the first test.

333. MANUAL COORDINATION. FINGER-FINGER TEST

A_1 series. — Many investigators have studied the disturbances of the neuromuscular coordination of the upper extremities resulting from intoxication with alcohol. As a rule, such studies have been concerned with visuo-motor coordination.

The finger-finger test, which does not involve the visual sense, has been provided with a quantitative method of evaluation by GOLDBERG (1943). To the left and right index finger of the subject a target and a needle were attached and the task, repeated 50 times, consisted of bringing them accurately together with closed eyes. The area pricked by the needle was measured with the planimeter.

In the present investigation GOLDBERG's method was used. As a precautionary measure against the suspected possibility of an effect upon the results from muscular fatigue, each test in the A_1 series was restricted to ten stabs, so as not to tire the subjects in the fairly strenuous experiments. The results were evaluated in the same manner as in GOLDBERG's test, dividing the measured area, in mm^2, by the number of stabs.

The average results and their ranges are seen in Table 10. No significant differences have been noted between the brandy and the beer experiments except at 240 minutes ($P = 0.05$), showing a renewed impairment in the beer experiment. Figure 12 shows the corresponding mean curves and the extreme values

TABLE 10. *Results of the finger-finger test, mm^2 per stab, in the brandy and beer experiments (A_1 series)*

	Time, minutes since commencement of ingestion				
	0	60	120	180	240
	Brandy expriments				
Mean	20.3	33.4	30.7	22.3	21.8
Lowest	10	15	13	14	14
Highest	44	69	53	35	38
	Beer experiments				
Mean	20.9	33.8	30.2	24.0	29.8
Lowest	11	17	9	10	9
Highest	40	59	55	47	55

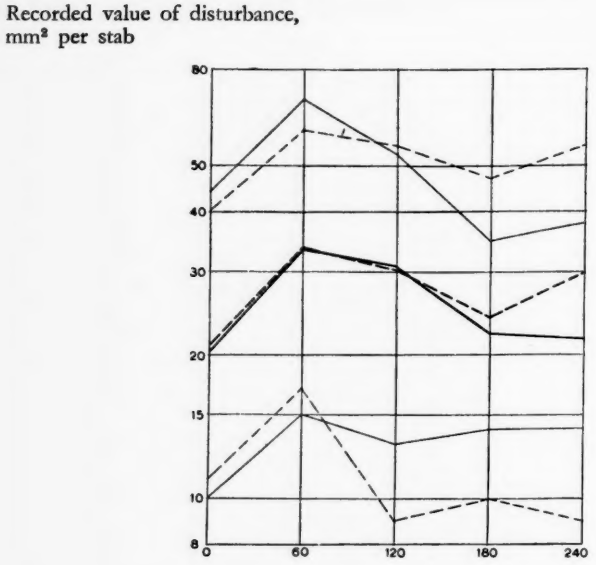

FIG. 12. *Results of the finger-finger test in the brandy and beer experiments, A_1 series.*

——— *Brandy experiments, mean values*
——— » » *highest and lowest*
– – – – *Beer experiments, mean values*
– – – – » » *highest and lowest*

A significant impairment of performance occurred between 0 and 60 minutes in both series (13.1; $P = 0.05$ and 12.8; $P = 0.02$ in the brandy and beer experiments, respectively). Another significant change is the improvement in the brandy experiments from 120 to 180 minutes (8.7; $P = 0.05$). No significant difference between series was demonstrable as to the changes of results from one time point to another.

A_2 series. — The manner in which the finger-finger test was applied in the A_1 series was found to have certain drawbacks. The area covered by a cluster of ten stabs only was not satisfactorily sensitive to reveal the differences. Moreover, this method of investigation is dependent on the subject's willingness to use his best endeavour and on other psychic factors (GOLDBERG, ALHA) to such an extent that no reliable results can be expected when the finger-finger test is part of an extensive series of investigations.

For this reason the finger-finger test was repeated with greater effort towards elimination of the potential sources of error and other disturbing factors. The experimental group comprised ten subjects (the same as in the B series), and the test was performed both in the brandy and the beer experiments.

The following points were observed in the arrangement of the test: No other tests were made in connection with the finger-finger test; even the taking of blood samples was not attempted so that its secondary effects on the results might be avoided. On the reasoning that no other neuromuscular tests were performed at the same time and that the dynamometer tests included in our present program (cf. p. 68) have shown it to be unnecessary to account for the effect of muscular fatigue even in the beer experiment, the subjects had to make fifty stabs as in GOLDBERG's original test. Prior to the test at 0 minutes each subject was allowed to perform two series of practice stabs with an interval of a few minutes. The brandy experiment was performed first with subjects No. 1 to 5 and the beer experiment with subjects No. 6 to 10, in order to eliminate the influence of training and habituation upon the results.

In order to make evident as accurately as possible in relation to time the occurrence of any potential impairment in performance during the ascending part of the blood alcohol curve, the tests were made at ten-minute intervals during the first hour, and then at 30-minute intervals. The last test was made at 150 minutes.

TABLE 11. *Results of the finger-finger test, mm² per stab, in the brandy and beer experiments (A_2 series)*

	Time, minutes since commencement of ingestion									
	0	10	20	30	40	50	60	90	120	150
	Brandy experiments									
Mean	2.8	3.0	3.6	3.7	4.2	4.9	5.9	4.8	4.2	3.6
Lowest	2.1	1.4	1.6	1.6	1.9	2.1	2.5	2.2	2.9	2.0
Highest	4.1	4.3	5.9	5.5	5.9	8.2	11.3	10.3	8.0	6.3
	Beer experiments									
Mean	3.0	3.1	3.7	3.6	4.1	4.1	4.2	5.2	5.0	5.4
Lowest	1.8	1.9	2.2	1.5	1.8	1.7	2.4	2.3	3.1	2.8
Highest	4.6	4.6	6.8	6.4	7.1	7.9	6.6	8.5	8.6	8.1

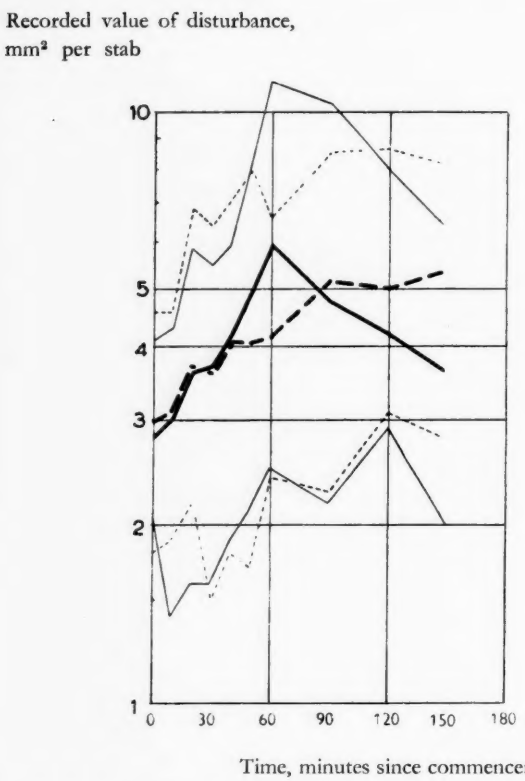

FIG. 13. *Results of the finger-finger test in the brandy and beer experiments, A_2 series.*

——— *Brandy experiments, mean values*
. . . . . » » *highest and lowest*
– – – – – *Beer experiments, mean values*
– . – . – . » » *highest and lowest*

Table 29 in the Appendix shows the individual performances at different times both in the brandy and the beer experiments, and Table 11 their mean values and ranges. Figure 13 gives a graphic representation of the mean curves and extreme values. The curves show a steeper rise which begins at 40 minutes in the brandy experiments, the maximum disturbance being observed at 60 minutes in this series. After this, the curve begins to descend slowly and reverts at 150 minutes close to its initial level. In the beer experiments, again, a slow ascent persists up to the end of the experiment. A peak may be suspected in the beer experiments

at 90 minutes. After this observation the performance retains approximately the same level.

The mean of the differences between the brandy and beer series is significant at 60 minutes (+1.7; $P = 0.05$) and at 120 and 150 minutes (—0.9; $P = 0.01$ and —1.8; $P = 0.01$, respectively).

The following results have been obtained from the finger-finger test in the A_2 series: Both in the brandy and the beer experiments a distinct impairment of the results can be observed, its peak occurring at 60 minutes in the brandy experiments, while in the beer experiments an impairment slightly less in degree occurs most markedly from 90 minutes onwards. In the brandy experiments the disturbed value at 60 minutes is about double compared to the initial values, and the range is strongly increased. In the beer experiments the impairment is less marked and develops at a slower rate. At 60 minutes the performance in the brandy experiments is significantly inferior to that in the beer experiments, while at 120 and 150 minutes the performances in the beer experiments are significantly inferior. At 150 minutes the performance in the brandy experiments has returned close to its initial level.

The disturbance has thus manifested itself strongly at an earlier time in the brandy series than in the beer series, although no very considerable difference seems to exist between the maximum levels. In the beer experiments the disturbance increases at a slower rate and persists longer than in the brandy experiments.

TABLE 12. *Results of the dynamometer test (C series)*
Mean sum of compressive forces of left and right hand, kg.

	Time, minutes since commencement of ingestion						
	0	30	60	90	120	150	180
Water experiment (9 subjects)	96.3	92.4	92.0	97.2	92.8	94.6	
Alcohol solution exp. (8 subjects)	90.5	91.9	92.6	88.5	89.2	87.1	
Beer experiment (9 subjects)	93.7	95.0	93.2	91.8	93.7	89.8	88.1

Dynamometer test (*C series*). — In the C series a dynamometric study was performed in order to establish the potential decrease in muscular hand pressure capacity caused by beer, in comparison with the experiments with water and with an alcohol solution of 3.2 per cent by weight. The dynamometer test was carried out at 0, 30, 60, 90, 120 and 150 minutes, the compression force readings for both hands obtained with the dynamometer (»Aesculap») being added together. The mean values from these determinations are shown in Table 12.

The only difference which is significant is that between the beer and water experiments at 150 minutes, namely, —4.8 kg ($P = 0.02$). This very slight impairment of performance in the beer experiments can be said to indicate primarily that muscular fatigue cannot be significantly responsible for the impairment of performance in the finger-finger test in the late stages of the beer experiments. Possibly also an effect of psychic unwillingness of effort and psychic fatigue is concerned.

334. MANUAL DEXTERITY

Widely varying methods of investigation have been used in order to record the visuo-manual coordination, e.g., the »Stichplatte», threading of pearls, threading of a needle, various types of steering mechanisms, target-aiming toy machines, etc., but in most cases the factorial composition of the functions recorded by these means has not been analysed. In the present investigation factorized dexterity tests have been employed for the recording of the disturbances of dexterity.

In order to eliminate the influence of training and fatigue and other extraneous effects, the study of the results from the metric tests (manual dexterity, finger dexterity, intelligence test) has been made on the basis of regression curves, shown in Figure 2, p. 31, which have been obtained from the performances of a control group (cf. p. 25).[1]

Method. — The Santa Ana dexterity test (MELTON 1947) was used in the experiments of the A_1 series. This test measures mainly »manual dexterity», i.e., the ability to perform skilfully movements of the hand and of the arm. This test is also partially determined by the »wrist-finger speed» factor (FLEISHMAN and HEMPEL 1954) and as a third factor the finger dexterity enters, i.e., the ability to coordinate the movements of the fingers in manipulations. In addition to this, the test requires coordination of eye

[1]) In a preliminary publication (TAKALA et al. 1957) the author has, in his presentation of results belonging to this part of the investigation, corrected the results by using the mean values of the control group as such.

and hand. Several factor analyses have been performed in the Institute of Occupational Health in order to determine the factorial composition of the dexterity tests. The Santa Ana dexterity test has always got high factor loading in analysis with other dexterity tests (HÄKKINEN, personal communication).

The testing equipment in the Santa Ana dexterity test consists of a wooden base-plate with square depressions in rows of 12, each depression carrying with accurate fit a peg which is cylindrical of its protruding part. The subject has the task to turn each peg in succession by 180 degrees. The result of the test is the number of pegs turned within a test period of 35 seconds, repeated three times at each testing. The test is performed with the dominant hand.

This test was performed at 0, 60, 120 and 180 minutes, similarly as the other metric tests which will be presented later.

TABLE 13. *Uncorrected results of the Santa Ana dexterity test in the brandy and beer experiments (A_1 series)*

	Time, minutes since commencement of ingestion			
	0	60	120	180
	Brandy experiments			
Mean	84.3	74.8	85.8	91.0
Lowest	66	56	67	66
Highest	103	100	105	113
	Beer experiments			
Mean	83.7	80.3	81.8	84.9
Lowest	67	67	71	72
Highest	102	105	109	109
	Difference Brandy minus beer experiments			
Mean	0.58	—5.5	4.1	6.1
Lowest	—14	—30	—11	—6
Highest	9	5	21	18
Mean error	2.1	3.0	2.7	2.6
t	0.28	1.85	1.52	2.36
P	..	..	..	0.05

TABLE 14. *Changes of uncorrected results of the Santa Ana dexterity test in the brandy and beer experiments (A_1 series)*

	Time interval, minutes since comm. of ingestion		
	0—60	60—120	120—180
	Brandy experiments		
Mean	—9.4	11.0	5.2
Lowest	—22	0	—3
Highest	1	33	18
Mean error	2.0	2.8	1.9
t	4.61	3.94	2.74
P	0.001	0.01	0.02
	Beer experiments		
Mean	—3.3	1.4	3.2
Lowest	—13	—12	—7
Highest	7	13	15
Mean error	2.1	2.1	1.8
t	1.57	0.67	1.78
P	..	..	..
	Difference Brandy minus beer experiments		
Mean	—6.1	9.6	2.0
Lowest	—22	—6	—10
Highest	8	36	19
Mean error	2.6	3.4	2.4
t	2.35	2.78	0.82
P	0.05	0.02	..

Uncorrected results. — The results obtained by each subject in both experiments at various times are shown in Table 30 in the Appendix. Table 13 gives the means and ranges of the results as well as the averages of their differences together with the significance tests, while Table 14 contains the same data with regard to the changes of the results and their differences.

No learning is observable between sessions on the basis of their initial values, i.e., the average of the differences relating to 0 minutes is not significant. A significant difference between the experiments does not appear before 180 minutes; this difference shows that the performance in the brandy experiment has im-

proved significantly in comparison with that of the beer experiment.

A study of these uncorrected results reveals a significant mean change in every time interval in the brandy series. The impairment of the results during the interval from 0 to 60 minutes, their improvement from 60 to 120 minutes, and their further improvement from 120 to 180 minutes are all statistically significant, whereas the changes in the beer experiment are not significant.

The differences between the changes of the uncorrected results (brandy series minus beer series) are found to be significant for the intervals 0 to 60 and 60 to 120 minutes, and it can be stated

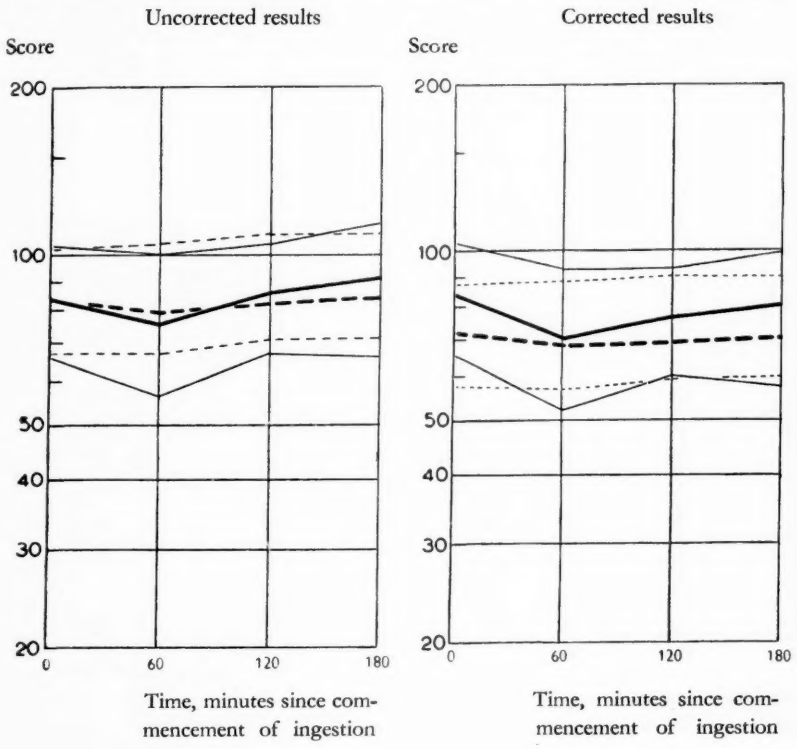

FIG. 14. *Results of the manual dexterity (Santa Ana) test in the brandy and beer experiments, A_1 series.*

Brandy experiments, mean values
» » *highest and lowest*
Beer experiments, mean values
» » *highest and lowest*

that the impairment of the results between 0 and 60 minutes in the brandy experiments has been more rapid than the corresponding nonsignificant impairment in the beer experiments. Similarly, the improvement of the results from 60 to 120 minutes in the brandy experiments is significantly greater than the nonsignificant improvement in the beer experiments. During the interval from 120 to 180 minutes the difference of the changes is not significant.

Figure 14 shows the mean curves from the results of the experimental group proper, uncorrected and corrected on the basis of the test results in the control group.

Corrected results. — Table 15 gives the corrected mean values and their differences, together with their significance tests.

It can be noted that the mean difference of the corrected values is significant at 0 minutes. The mean differences are also significant at 120 and 180 minutes. The significant difference of the performances at 0 minutes shows that the improvement of the mean results, which must be attributed to training between sessions, has been absent in the experimental groups proper, as compared with the results of the control group. At 60 minutes, where the results have become inferior (particularly in the brandy series), the corrected values show no significant differences. In the later

TABLE 15. *Corrected results of the Santa Ana dexterity test in the brandy and beer experiments* (A_1 *series*)

	Time, minutes since commencement of ingestion			
	0	60	120	180
	Brandy experiments			
Mean	84.3	70.3	77.2	80.1
	Beer experiments			
Mean	72.0	68.3	68.7	70.5
	Difference *Brandy minus beer experiments*			
Mean	12.3	2.0	8.5	9.6
Mean error	2.0	2.7	2.3	2.2
t	6.2	0.7	3.7	4.4
P	0.001	..	0.01	0.001

tests, both at 120 and 180 minutes, the difference is again significant, owing to the fact that especially due to the rapid improvement of the performance in the brandy experiments after its impairment at 60 minutes the performance in the beer experiments has significantly lagged behind.

Table 16 shows the corrected mean changes in the brandy and beer experiments from one point of time to another. It can be seen that in the brandy experiments the change from 0 to 60 minutes is significant, as well as that from 60 to 120 minutes. On the other hand, the change from 120 to 180 minutes is not significant any more in the brandy series. It is seen in agreement with the uncorrected results that the corrected changes in the beer experiments are not significant at any time.

Table 16 also contains the differences of the changes of the corrected results, which are significant in the intervals from 0 to 60 and from 60 to 120 minutes. Even according to the corrected

TABLE 16. *Changes of corrected results of the Santa Ana dexterity test in the brandy and beer experiments (A_1 series)*

	Time interval, minutes since comm. of ingestion		
	0—60	60—120	120—180
	Brandy experiments		
Mean	—14.0	6.9	2.9
Mean error	1.9	2.6	1.7
t	7.4	2.7	1.7
P	0.001	0.02	..
	Beer experiments		
Mean	—3.7	0.4	1.8
Mean error	1.8	1.8	1.5
t	2.1	0.2	1.2
P	..	..	..
	Difference *Brandy minus beer experiments*		
Mean	—10.3	6.5	1.1
Mean error	2.4	3.0	2.1
t	4.3	2.2	0.5
P	0.01	0.05	..

results, thus, the impairment of performance in the brandy experiments between 0 and 60 minutes has occurred at a significantly higher rate than the corresponding change in the beer experiments. Similarly, the improvement between 60 and 120 minutes represents a more rapid change in the brandy than in the beer experiment, as was already indicated by the uncorrected results.

Range of variation. — A study of the range of variation of the uncorrected results at different times in the brandy and the beer experiments reveals that this range remains comparatively constant throughout the beer experiment. In the brandy experiments the range has considerably increased at 60 minutes from its initial value. At 120 minutes it reverts nearly to its initial value, being once more greater at 180 minutes.

At 60 minutes the increase in range of variation in the brandy series is primarily due to reduction of the lowest value, resulting from an impairment by 10 points of the result of a subject who gave the lowest performance at 0 minutes. At 120 minutes the performance of the same subject has improved; even at this time it constitutes the lower variation limit.

At 180 minutes the increase of range is mainly due to improvement of the highest performance as compared to the initial value. Here a subject who has scored best at all times both in the brandy and the beer experiment has improved his result with 10 points from the initial value.

In the beer experiments only a slight increase in range seems to occur compared to the initial value, primarily owing to a slight improvement of the maximum performance.

Range of variation of changes. — The range of variation of the changes is fairly constantly of the same order of magnitude both in the brandy and the beer experiments. Only during the interval from 60 to 120 minutes, which constitutes a period of recovery in both series after the point of the lowest mean values, the ranges have increased, this being particularly the case in the brandy series. This shows considerable individual differences in the rate of recovery from the disturbance concerned.

Condensed findings. — The following statements can be made on the basis of the manual dexterity test.

The uncorrected mean values in the brandy and the beer experiments at 0 minutes are not significantly different. According to them thus no training effect is observable.

Since the time intervals between the various sessions were not identical with that between the experiments with the control group, the correction cannot be made quite exactly. If the corrected results are considered, it can be seen that the mean value

in the beer experiments at 0 minutes is significantly smaller than that of the brandy experiments, thus also showing that no learning has taken place between these experiments in any degree corresponding to the improvement of results from one session of the control group to another.

The impairment of the mean result in the brandy experiments during the interval from 0 to 60 minutes is statistically significant. This is also true of the improvement of the mean result in the brandy experiments between 60 and 120 minutes on the basis of the corrected as well as the uncorrected values. On the other hand the impairment of the mean result from 0 to 60 minutes observed in the beer experiments and the subsequent slight improvements from 60 to 120 minutes and from 120 to 180 minutes are not statistically significant (neither on the basis of the uncorrected nor of the corrected values).

The results of the brandy and beer experiments are significantly different at 180 minutes, both according to the uncorrected and the corrected values, the result being higher in the brandy than in the beer experiment. Consequently, when the time of 180 minutes has been reached, the recovery in the brandy experiment has progressed so far as to leave the performance in the beer experiment behind in a statistically significant degree.

Considering the corrected values, the results are not significantly different at 60 minutes, but a significant difference exists at all other times. In the brandy experiments the impairment is at its greatest at 60 minutes, and the performance has then subsided to the level of the »corrected» beer experiment.

The differences of the changes of the results (brandy series minus beer series) during the interval from 0 to 60 minutes when the mean results went down in both series, and during the interval from 60 to 120 minutes when the results improved in both series, are significant on the basis of the uncorrected as well as the corrected values. The impairment of performance in the brandy experiments during the first hour, and similarly the recovery during the second hour, have thus occurred at a higher rate than in the beer experiments. The changes during the third hour are not significantly different, and no difference is thus observable in the slope of the curves between 120 and 180 minutes.

Synopsis. — As a summary of the foregoing it can be noted that the disturbance of manual dexterity has been stronger and more abrupt in the case of brandy than in that of beer during the first hour. The recovery was also more rapid, and stronger, in the brandy experiments.

It is possible that the absence of learning from one session to another, as reflected by the equal initial values, is due to the influence of brandy. On the other hand this may be partly attributable to the longer interval between these experiments as compared with that between the experiments of the control group.

The disturbance of performance in the beer experiments is smaller and not statistically significant. However, throughout the beer experiment the improvement of the results is prevented, in contrast with the brandy experiment.

335. FINGER DEXTERITY

Method. — In order to study the potential disturbances of finger dexterity, O'Connor's finger dexterity test (TIFFIN 1944) was performed at 0, 60, 120 and 180 minutes. According to performed factor analysis (FLEISHMAN and HEMPEL) the test has relation to a functional entity, the main factor of which is »finger dexterity» and in addition to this also »manual dexterity», wrist-finger speed», »positioning», and »aiming». The factor analysis performed by the Institute of Occupational Health points to finger dexterity as being mainly concerned. The test is positively correlated with the Santa Ana Dexterity test ($r = 0.30$—0.40).

In this test small pins are put (with the dominant hand) into holes arranged in rows in a square plate, three into each. The score is the number of pins placed in five minutes.

Uncorrected results. — Table 31 in the Appendix shows the individual scores at various times in both experimental series. Table 17 shows the arithmetic means and ranges of the results and their differences, and Table 18 the means and differences (brandy series minus beer series) of the changes.

It can be seen that there is a difference of —5.7 points between the means of the initial tests. However, this difference is not significant, although indicative of a strong tendency. It may be

TABLE 17. *Uncorrected results of the finger dexterity test in the brandy and beer experiments (A_1 series)*

	Time, minutes since commencement of ingestion			
	0	60	120	180
	Brandy experiments			
Mean	49.5	42.4	48.8	48.7
Lowest	36	33	34	26
Highest	59	53	63	60
	Beer experiments			
Mean	55.2	47.9	50.2	51.6
Lowest	41	39	32	29
Highest	72	56	61	60
	Difference *Brandy minus beer experiments*			
Mean	—5.7	—5.5	—1.3	—2.9
Lowest	—20	—19	—19	—34
Highest	8	10	11	17
Mean error	2.8	2.3	2.7	4.0
t	2.06	2.41	0.50	0.74
P	..	0.05	..	..

considered as indicating that a certain effect of learning has occurred between the brandy and the beer experiments. Thus a proper comparison of the results is difficult without taking recourse to the results of the control groups. At 60 minutes the uncorrected results between the experimental series show a significant difference.

A further study of the uncorrected results shows that in the brandy experiments the changes from 0 to 60 and from 60 to 120 minutes are significant. The change observed during the third hour is not significant any more. In the beer experiments the change from 0 to 60 minutes is significant, but not those during any other interval.

At a study of the differences, between the brandy and the beer experiments, of the changes of the uncorrected results, it can be noted that these differences are not significant during any interval.

TABLE 18. *Changes of uncorrected results of the finger dexterity test in the brandy and beer experiments (A_1 series)*

	Time interval, minutes since comm. of ingestion		
	0—60	60—120	120—180
	Brandy experiments		
Mean	—7.1	6.4	—0.17
Lowest	—16	—7	—10
Highest	—3	15	10
Mean error	1.6	1.6	1.6
t	4.38	3.93	0.11
P	0.01	0.01	..
	Beer experiments		
Mean	0.17	4.2	—1.6
Lowest	—17	—12	—15
Highest	15	18	13
Mean error	2.8	2.2	2.2
t	0.060	1.90	0.73
P	..	..	..
	Difference Brandy minus beer experiments		
Mean	—7.2	2.2	1.4
Lowest	—19	—11	—5
Highest	8	15	8
Mean error	2.1	1.9	1.1
t	3.46	1.16	1.31
P	0.01	..	..

However, a tendency towards an indication of a greater change in the brandy experiments is observed in the interval from 60 to 120 minutes.

Figure 15 shows both the uncorrected and corrected mean curves.

Corrected results. — After correction of the actual experimental results with the aid of the results of the control group, the corrected mean results with their differences shown in Table 19 are obtained. The table shows that the corrected results are not significantly different at any time. The tendency towards a difference is strongest at 0 minutes.

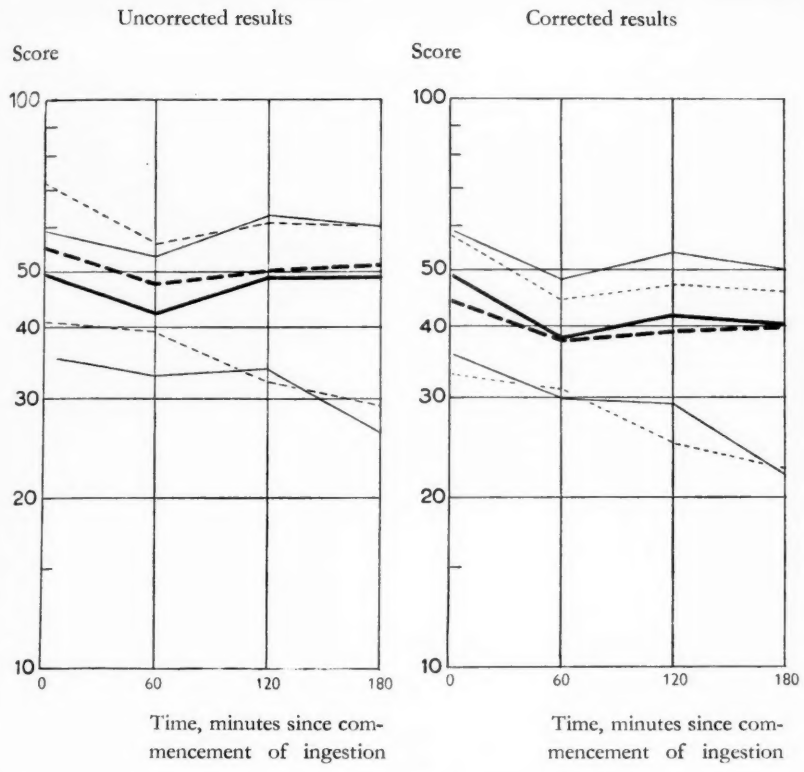

FIG. 15. *Results of the finger dexterity (O'Connor) test in the brandy and beer experiments, A_1 series.*

——— *Brandy experiments, mean values*
——— » » *highest and lowest*
– – – – *Beer experiments, mean values*
– – – – » » *highest and lowest*

Table 20 shows the mean changes of the corrected results during the different intervals, and their differences. The change is significant during the interval from 0 to 60 minutes in both series. The difference of these changes is not significant. The mean change is significant in the brandy experiments also during the period from 60 to 120 minutes, but no more in the beer experiments. The difference between the changes during this interval is not significant. The changes during the third hour are not significant in either series.

TABLE 19. *Corrected results of the finger dexterity test in the brandy and beer experiments (A_1 series)*

	Time, minutes since commencement of ingestion			
	0	60	120	180
	Brandy experiments			
Mean	49.5	38.6	42.0	40.9
	Beer experiments			
Mean	44.7	38.3	39.2	39.7
	Difference Brandy minus beer experiments			
Mean	4.8	0.3	2.8	1.2
Mean error	2.5	2.0	2.2	3.2
t	1.9	0.2	1.3	0.4
P	..	..	..	..

TABLE 20. *Changes of corrected results of the finger dexterity test in the brandy and beer experiments (A_1 series)*

	Time interval, minutes since comm. of ingestion		
	0—60	60—120	120—180
	Brandy experiments		
Mean	—10.9	3.4	—1.1
Mean error	1.5	1.4	1.4
t	7.3	2.4	0.8
P	0.001	0.05	..
	Beer experiments		
Mean	—6.4	0.9	0.5
Mean error	1.7	1.5	0.86
t	3.8	0.6	0.6
P	0.01	..	..
	Difference Brandy minus beer experiments		
Mean	—4.5	2.5	—1.6
Mean error	2.5	1.8	1.8
t	1.8	1.4	0.9
P	..	..	..

Range of variation. — It can be noted that the range of variation in both experiments increases at the last two time points. No increase of the range was observed in the brandy experiments at 60 minutes as was the case with regard to the blood alcohol, to swaying, to the finger-finger test, and to the Santa Ana dexterity test. At later times, on the other hand, the range of variation is somewhat greater.

The comparatively wide range at 0 minutes in the beer experiments is due to the high result of one single subject who also scored highest at all times in both experiments in the Santa Ana test. Its decrease at 60 minutes is caused by the impairment of the maximum result. At the next time point the range increases once more owing to the impairment of the results of one subject and because one subject causes a rise of the upper limit. At the last time point the range is equal to that at 0 minutes, but the level of the results is consistently lower.

Range of variation of changes. — In the brandy experiments the changes showed the greatest range of variation during the second and third hour, and in the beer experiments during the first and second hour.

Condensed findings and synopsis. — Both in the brandy and the beer experiments a significant impairment of finger dexterity can be observed. No distinct statistical difference between the experimental series has been established.

In the brandy experiments the recovery during the second hour is significant, but not in the beer experiments, although no significant difference exists between the changes in the brandy and the beer experiments during this interval.

336. INTELLECTUAL PERFORMANCE

Method. — In order to study the potential differences in intellectual performance, the so-called square test designed in the Institute of Occupational Health for the purpose of group testing was performed in the A_1 series both in the brandy and the beer experiments at 0, 60, 120 and 180 minutes.

The square test represents a two-dimensional derivative of KOHS' three-dimensional cube test. Instead of cubes, cardboard squares are used. They are of four different types of colouring, namely, uniformly black, uniformly white, diagonally divided into a black and a white triangle, or divided into a black and a white rectangle (Figure 16). The task of the subject is to assemble of the squares in 10 minutes figures after numerous varying patterns designed by MR. SAULI HÄKKINEN, M.Sc., of the Institute of Occupational Health. These figures being as similar as possible in character and degree of difficulty, the test can be repeated

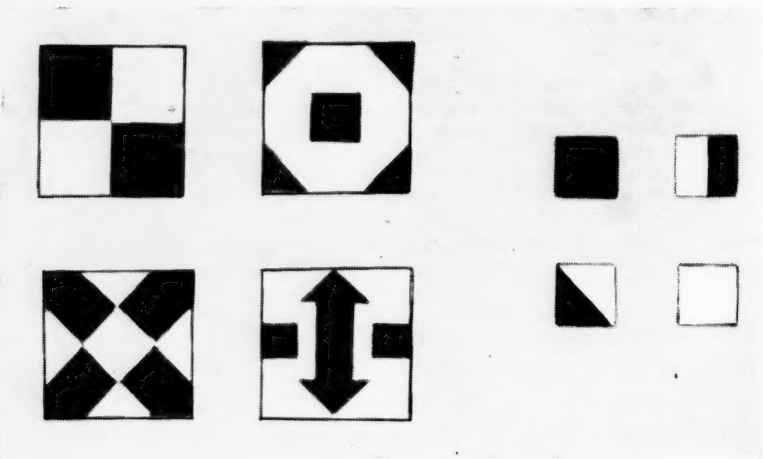

FIG. 16. *The square test employed in the study of intellectual performance.*

several times with the same subject. The test is based on the function of visual analysis and combination, and it is a pure non-verbal intelligence test. The square test correlates with the WECHSLER-BELLEVUE Form 1 Block Design Test ($r = +0.75$).

A test of the type of the square test appears suitable for an investigation of this kind. Being rapidly performed, it is easy to interpose between other tests. Its variability allows it to be reapted several times, and its non-verbality renders the chances of people on different verbal levels equal. It is also both amusing and interesting and constitutes a considerable stimulation towards efficient performance during the session.

Each variation contains eight partial tasks, and points are given for each one of them. The time of performance of the partial tasks is not limited, but the total time of the test is ten minutes. If the subject finishes his test earlier, additional points are awarded. The maximum score is 16, but the recompense of time can bring it up to 20 points or even more. Only the accomplishment of the figures is considered in this test, not any wrong movements.

Uncorrected results. — Table 32 in the Appendix shows the

TABLE 21. *Uncorrected results of the square test in the brandy and beer experiments (A_1 series)*

	Time, minutes since commencement of ingestion			
	0	60	120	180
	Brandy experiments			
Mean	10.8	10.7	10.5	11.6
Lowest	2	6	4	5
Highest	18	15	18	18
	Beer experiments			
Mean	10.8	11.6	11.4	13.0
Lowest	4	5	5	5
Highest	18	18	18	18
	Difference *Brandy minus beer experiments*			
Mean	0.0	—0.92	—0.92	—1.4
Lowest	—9	—8	—5	—9
Highest	5	5	4	8
Mean error	1.2	1.3	0.84	1.3
t	0.00	0.69	1.10	1.08
P	..	..	..	..

individual results of each subject at successive points of time, and Table 21 the arithmetic means and ranges.

It can be observed that the average at 0 minutes is the same in both series. In the brandy experiments the score remains practically the same at 60 and 120 minutes and rises very slightly at 180 minutes. In the beer experiments the initial average is lowest. At 60 minutes and at 120 minutes it rises a little and at 180 minutes somewhat more.

Table 21 also gives the differences of the uncorrected results and Table 22 the changes of the results, and their differences.

The averages of the initial performances do not differ, and thus no effect of learning between sessions is likely to have occurred. It can also be seen that the means of the differences are not significantly different at any later time either.

The changes of the results are not statistically significant in either series at any time, nor are the averages of the differences of the changes.

TABLE 22. *Changes of uncorrected results of the square test in the brandy and beer experiments (A_1 series)*

	Time interval, minutes since comm. of ingestion		
	0—60	60—120	120—180
	Brandy experiments		
Mean	—0.17	—0.17	1.1
Lowest	—7	—6	—6
Highest	5	5	7
Mean error	1.1	1.2	1.2
t	0.15	0.14	0.92
P	..	..	..
	Beer experiments		
Mean	0.75	—0.17	1.6
Lowest	—8	—7	—4
Highest	5	7	9
Mean error	1.1	1.1	1.1
t	0.68	0.15	1.45
P	..	..	..
	Difference Brandy minus beer experiments		
Mean	—0.92	0.0	—0.50
Lowest	—8	—9	—9
Highest	8	10	11
Mean error	1.3	1.8	1.6
t	0.74	0.00	0.32
P	..	..	..

Figure 17 shows the course of the mean curves from the uncorrected and corrected values.

Corrected results. — Table 23 shows the average results corrected with the aid of the results of the control group, as well as the difference of the averages. At 0 minutes the difference of the corrected mean values is statistically significant, but not at any other time. The significant difference at 0 minutes is due to the fact that in the control group a marked improvement of the results has taken place between sessions. No such effect of learning was demonstrable between the brandy and the beer experiments.

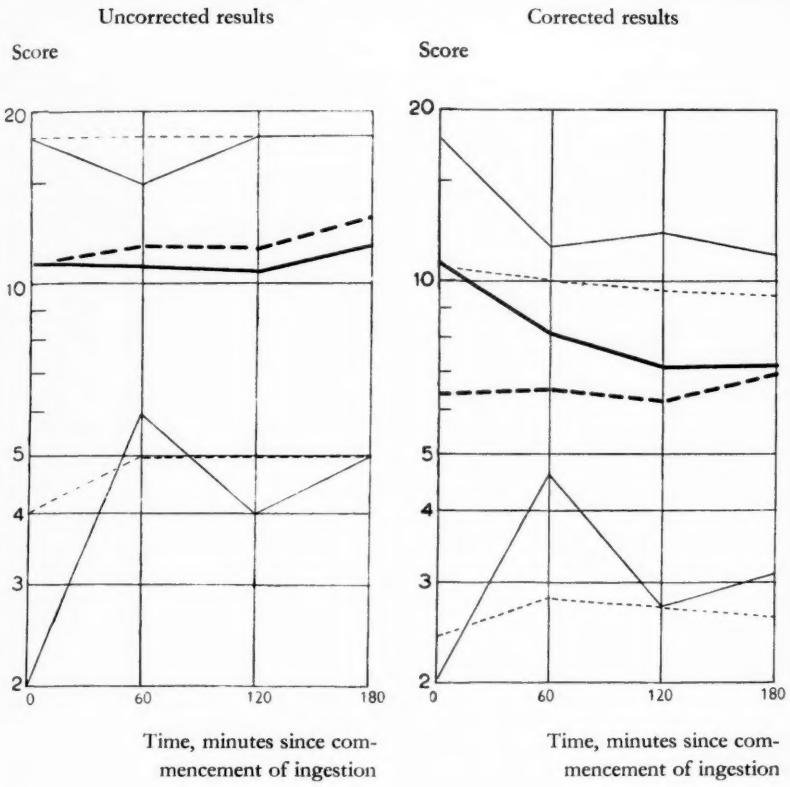

FIG. 17. *Results of the intellectual performance test (square test) in the brandy and beer experiments, A_1 series.*

——— *Brandy experiments, mean values*
» » *highest and lowest*
– – – – *Beer experiments, mean values*
» » *highest and lowest*

Table 24 shows the average changes of the corrected results at successive points of time and their differences. In the brandy experiments a significant impairment has occurred during the first hour. No corresponding significant impairment can be observed in the beer experiments, nor are any other significant changes demonstrable in either series. The difference of the changes between the brandy and the beer experiments (brandy series minus beer series) is significant during the first hour.

TABLE 23. *Corrected results of the square test in the brandy and beer experiments (A_1 series)*

	Time, minutes since commencement of ingestion			
	0	60	120	180
	Brandy experiments			
Mean	10.8	8.2	7.1	7.2
	Beer experiments			
Mean	6.4	6.5	6.2	6.9
	Difference Brandy minus beer experiments			
Mean	4.4	1.7	0.9	0.3
Mean error	0.96	0.86	0.51	0.75
t	4.6	2.0	1.8	0.4
P	0.001	..	..	..

TABLE 24. *Changes of corrected results of the square test in the brandy and beer experiments (A_1 series)*

	Time interval, minutes since commencement of ingestion		
	0—60	60—120	120—180
	Brandy experiments		
Mean	—2.6	—1.1	0.1
Mean error	0.97	0.86	0.78
t	2.7	1.3	0.1
P	0.02	..	..
	Beer experiments		
Mean	0.1	—0.3	0.7
Mean error	0.64	0.60	0.59
t	0.2	0.5	1.2
P	..	..	..
	Difference Brandy minus beer experiments		
Mean	—2.7	—0.8	—0.6
Mean error	0.95	1.2	0.96
t	2.8	0.7	0.6
P	0.02	..	..

Range of variation. — A study of the ranges shows that in the brandy experiments the range is greatest at 0 minutes, owing to the low result of one subject. At 60 minutes the range has diminished, which is a result of the impairment of the highest score and of the improvement of the result of the mentioned subject. Practically no changes of range occur in the beer experiments.

Range of variation of changes. — The range of variation of the changes is very closely equal in the brandy and beer experiments in all time intervals.

Condensed findings and synopsis. — The following results have been obtained in the square test: The significant difference of the mean values at 0 minutes shows that no learning has occurred between the brandy and the beer experiments, as has been the case between the sessions of the control group. This may be partly due to the comparatively long interval between some of these experiments. However, it is probable that the influence of the brandy has prevented the effect of learning.

According to the corrected values, the change of the result during the first hour is significantly greater in the brandy than in the beer experiments, showing that the intellectual performance investigated in this study has been more strongly disturbed by brandy than by beer during the first hour after the ingestion of alcohol. During the other intervals no significant differences of the changes could be established between the brandy and the beer experiments.

In addition to its effect of preventing the normal improvement of the results, brandy has probably also inhibited the occurrence of learning of persistent influence. The influence of beer during the first hour has been less marked, but it has similarly prevented normal improvement during the experiment. In both series the maximum disturbance has occurred at 120 minutes. No remarkable change occurs after this time.

34. CLINICAL OBSERVATIONS

Certain observations, which the author was not inclined to forego on account of their interest and significance, had to be based on subjective clinical evalutions alone, which are necessarily rather unreliable and arbitrary. However, when one and the same person — in this case the author — performs all the assessments, it is quite conceivable that the subjective errors may be similar of

direction as a rule, and thus cancel out in a comparison. It is a quite general practice, e.g. in the clinical psychiatric study of the effects of medicines to base the rating of phenomena of this kind on intuitive estimations. More objective results might undoubtedly have been obtained with the aid of certain testing methods, but in view of the ample program of study and the secondary importance of this detail question it was decided to employ only the said procedure to preserve these observations, fully aware of their rather slight scientific significance.

As has been mentioned before, best attempts were made to arrange the experimental conditions in a way that would maintain the morale during the tests. Even in spite of stimulating arrangements, however, experiments of several hours' duration together with blood sampling and performance tests tend to produce fatigue and listlessness in the subjects. Even so, it should be possible to make general comparisons, considering that the conditions were identical in the brandy and the beer experiments.

341. DISTURBANCE OF SPEECH

Various disturbances of speech are a typical clinical manifestation of the effect of alcohol, to which many investigators have paid attention, but owing to the varying dosages and methods of observation no mutually comparable results can be found in the literature. Neither has so far any attention been centred on any one among the component functions of the multi-dimensional entity of speech.

WIDMARK (1932) reported disturbances of speech in about 50 per cent of the experimental subjects when the blood alcohol was 2.3 per mil. CARLSON et al. (1934), in their previously mentioned experiments with beer, noted disturbances of speech in many subjects at a blood alcohol figure of about 1.2 per mil, as did also ABRAMSSON (1945) with a whisky dosis of about 85 ml. ALHA (1951), again, established an increasing occurrence of speech disturbances with increasing alcohol doses. Also in GOLDBERG's (1951) experiments with brewed beverages, disturbances of speech were observed in some subjects.

In a specialized study on the disturbances of speech an exact recording method should be applied to some more accurately definable component function of speech motorics. In the present work no such study was intended, nor was it desirable to accloy with additional, more objective methods of recording the program of in-

vestigation, which was quite ample as such. However, it was considered worth while to observe and assess also the potential disturbances of speech with the aid of rough clinical means, in order to obtain a summary comparison between the brandy and beer series if positive findings were forthcoming.

The disturbances of speech were evaluated within about three minutes after each blood sample had been taken; at the same time also the tendency of mood of the subjects was observed.

The disturbances of speech were tested by having the subject repeat at each stage of the experiment two difficult phrases (1: *Kolmas ratsastava kaartin rakuunarykmentti*, 2: *Nakkilan pappilan apupapin papupata*).

The following points were observed: stumbling over syllables, disturbances in the rate of speech, such as considerable bradylalia, disturbances or changes in the rhythm of speech, or in the level or strength of the voice, different forms of dysarthria such as scanning, etc.

On the whole, the observed disturbances were slight, though brandy seemed to cause a more marked disturbance than beer. The slight disturbance in the beer experiments seemed to last longer than that produced by brandy. One quarter of the experimental population displayed no disturbances of speech observable by means of the method employed, either in the brandy or in the beer experiment. Only three subjects showed a marked disturbance of speech at 60 minutes in the brandy experiment and one subject in the beer experiment, and one subject at 120 minutes in the brandy experiment.

342. MOOD OF THE SUBJECTS

A_1 series. — In the A_1 series the changes of mood of the subjects were followed in order to assess their emotional state with particular reference to alcohol euphoria. This was done during talks with the subject between the taking of the blood samples and the determinations of pulse rate and blood pressure at 0, 60, 120, and 240 minutes.

Even though in a noticeably euphoric state, some subjects complained of disturbing physical sensations at various points of time. As far as possible, the degree of mood was assessed »apart from physical well-being», although it was found to be difficult

in many cases, particularly towards the end of the experiment, to make a distinction between »pure physical weariness» and a listless, slightly depressive mood (c.f. e.g. EHRSTRÖM 1949).

It may be useful to note the mood of the subjects in connection with the study of other experimental results as well. In some instances weariness and reluctance were evident toward the end of the experiment, and this may have affected the experimental results in some respects.

The observations relating to the mood of the subjects are shown in the table below:

		Mood					Subjects altogether
		Clearly depressed	Slightly depressed	Neutral	Slightly exalted	Clearly exalted	
		Number of subjects					
0 minutes	Brandy	0	0	12	0	0	12
	Beer	0	1	11	0	0	12
60 minutes	Brandy	0	1	0	9	2	12
	Beer	0	0	5	7	0	12
120 minutes	Brandy	0	1	3	7	1	12
	Beer	0	3	4	4	1	12
180 minutes	Brandy	0	3	7	2	0	12
	Beer	0	6	4	2	0	12
240 minutes	Brandy	0	7	5	0	0	12
	Beer	0	9	3	0	0	12

In the brandy experiments a stronger euphoria was observed than in the beer experiments.

Towards the end of the beer experiments a somewhat more marked dejection, obviously connected with the feeling of fatigue, was observed than in the brandy experiments.

In the brandy experiments a distinctly stronger erethitic component was observable in connection with euphoria than in the beer experiments. On the other hand, beer seemed to have a stronger sedative effect. The lowering of spirits towards the end of the beer experiments did not show any signs of irritation or stronger melancholy, but it was rather characterized by a certain languid reluctance and lessening of initiative.

C series. — Similarly as in the A_1 series, the development of the mood of the subjects was followed also in the C series, particularly in the beer and alcohol solution experiments.

The assessment was performed in the same manner as before, at the times 0, 30, 60, 90, 120 and 150 minutes, and the results are shown in the table below. Only the results of the nine persons who attended both experiments are included.

		Mood					Subjects altogether
		Clearly depressed	Slightly depressed	Neutral	Slightly exalted	Clearly exalted	
		Number of subjects					
0 minutes	Beer	0	0	9	0	0	9
	Alc.sol.	0	0	9	0	0	9
30 minutes	Beer	0	0	2	7	0	9
	Alc.sol.	0	0	0	8	1	9
60 minutes	Beer	0	0	0	5	4	9
	Alc.sol.	0	0	0	2	7	9
90 minutes	Beer	0	0	0	5	4	9
	Alc.sol.	0	0	0	2	7	9
120 minutes	Beer	0	0	2	6	1	9
	Alc.sol.	0	0	1	5	3	9
150 minutes	Beer	0	4	4	1	0	9
	Alc.sol.	0	1	5	3	0	9

As can be seen from the table, it is obvious that alcohol solution caused a euphoric state of greater strength and longer duration than beer. The same observations as before in the A_1 series were made with regard to the sedative quality of beer. During the decline of mood, a certain laxity and lack of initiative prevailed in the beer experiments. In the alcohol solution experiments, again, the subjects behaved much more lively and unrestrainedly.

343. PHYSICAL SENSATIONS

A_1 series. — Simultaneously with the study of the trend of mood of the subjects during the experiments, it was attempted, by general appraisal, to arrive at an idea of some physical sensations of each subject at different times during the experiment on the

basis of the subject's own statements. Attention was paid to a feeling of repletion in the epigastrium, to possible nausea and need to vomit, and to fatigue.

It is obvious that this study of estimative character can primarily claim only clinical significance. A more detailed analysis of the aspects involved was not possible on account of lack of time and other similar reasons. The observations which could be made are seen from the following table:

		Number of subjects with:				Subjects altogether
		Strong feeling of repletion in the epigastrium	Feeling of repletion in the epigastrium	Nausea, need to vomit	Fatigue	
0 minutes	Brandy	0	0	0	0	12
	Beer	0	0	0	0	12
60 minutes	Brandy	0	0	1	0	12
	Beer	4	3	2	0	12
120 minutes	Brandy	0	0	0	1	12
	Beer	0	0	0	3	12
180 minutes	Brandy	0	0	0	2	12
	Beer	0	0	0	5	12
240 minutes	Brandy	0	0	0	3	12
	Beer	0	0	0	8	12

The main inferences which can be drawn from this table are as follows: Beer caused a feeling of repletion in the epigastrium to more numerous subjects, and in a stronger degree, than brandy. Similarly, fatigue occurred with much greater frequency in the late stages of the beer experiment than towards the end of the brandy experiments.

C series. — Similarly as in the A_1 series, the »physical well-being» of the experimental subjects was followed also in the experiments of the C series. The findings are seen in the table below.

		Number of subjects with:				Subjects altogether
		Strong feeling of repletion in the epigastrium	Feeling of repletion in the epigastrium	Nausea, need to vomit	Fatigue	
0 minutes	Water	0	0	0	0	9
	Beer	0	0	0	0	9
	Alc.sol.	0	0	0	0	9
30 minutes	Water	0	2	0	0	9
	Beer	0	5	1	0	9
	Alc.sol.	0	1	0	0	9
60 minutes	Water	2	2	0	0	9
	Beer	5	4	2	0	9
	Alc.sol.	2	1	1	0	9
90 minutes	Water	0	0	0	1	9
	Beer	2	1	0	1	9
	Alc.sol.	0	1	0	0	9
120 minutes	Water	0	0	0	0	9
	Beer	0	0	0	3	9
	Alc.sol.	0	0	0	0	9
150 minutes	Water	0	0	0	0	9
	Beer	0	0	0	4	9
	Alc.sol.	0	0	0	1	9

In the beer experiments, repletion in the epigastrium was felt particularly at 30 and 60 minutes since the commencement of the experiment, and this feeling was assessed as strong in five cases at 60 minutes. In this respect, beer had a distinctly different effect from that observed in the water as well as the alcohol solution experiments. Another difference is observed in that fatigue occurred almost only in the beer experiments in a late stage of the experiment.

4. A STUDY ON THE MOTILITY OF THE STOMACH

The distinctly different course of the blood alcohol curve in the brandy and beer experiments established in the foregoing on one hand, and on the other hand the circumstance that the experimental beverages employed were greatly different from each other both qualitatively and quantitatively, made it appear motivated to complement the investigation with a closer study of the motility of the stomach under similar experimental conditions, paying particular attention to the rate of evacuation of the stomach.

41. EARLIER INVESTIGATIONS

Alcohol absorption has been studied in numerous ways, many of the investigators having concerned themselves immediately with the gastrointestinal canal and its various parts mainly in their experiments with animals. In experiments performed with man, however, the conditions prevailing in the gastrointestinal canal have only rarely been observed or recorded directly; on the contrary, the conclusions relating to the same have mostly been drawn from the changes of the blood alcohol.

Several investigators (e. g. MELLANBY 1919, WIDMARK 1932, JUNGMICHEL 1933) have considered that the absorption of alcohol is completed after the blood alcohol curve has reached its peak, but in opposition to this others (HAGGARD and GREENBERG 1934, MAYER 1936, HAGGARD, GREENBERG and LOLLI 1941) have expressly claimed that this contention involves great risks of error; HAGGARD et al. have observed in

their experiments that the absorption may continue for several (up to six) hours after the blood alcohol curve has reached its maximum. This should be true, e.g., in relation to beer. The opinion of HAGGARD et al., again, has been critised by other investigators (e.g. HARGER and HULPIEU 1935).

The concentration of the solution or beverage employed, its total quantity and its congeners, particularly the nutrients contained in the stomach at the same time (cf. p. 112), and the motility of the gastrointestinal canal have been found to influence the rate of absorption, particularly so the rate of evacuation of the stomach (e.g. CORI, VILLIAUME and CORI 1930, TUOVINEN 1930, JUNGMICHEL 1933, MAYER 1936, HAGGARD, GREENBERG and COHEN 1938, HAGGARD, GREENBERG and LOLLI 1941, BERGGREN and GOLDBERG 1940, GOLDBERG 1943, 1951). The absorption of alcohol is rapid from the small intestine, particularly from the jejunum (NEMSER 1907, HANZLICK and COLLINS 1913, etc.), which is obviously attributable to the large diffusion area (e.g. GOLDBERG 1951). As has been said before, the slow resorption, among others, of beer has been ascribed to its alleged tendency to cause delayed evacuation of the stomach (HAGGARD et al. 1938, 1941). HAGGARD et al. (1938) have placed this in conjunction with the buffer capacity of the beverage (cf. p. 116).

The effect of alcohol itself upon the motility of the stomach and even upon the secretive functions has already received attention from the earlier investigators (KLEMPERER 1890, HAAN 1895, etc.). The investigators have found the concentration as well as the quantity of the solution to have significance with regard to the resulting effect upon the motility of the stomach (FRANZEN 1928, CORI et al. 1930, FRIEDRICH and BOKOR 1933, GOLDBERG 1951, etc.; cf. also p. 111). Several investigators have observed particularly at an increase in concentration of the solution the occurrence of a delay in the evacuation of the stomach (FRANZEN 1928, CORI etc.), and it has been attempted to decide whether a local effect in the stomach itself is concerned or a change in a central regulatory mechanism (GRAF and FLAKE 1933, MAYER 1936, TENNENT 1941, GREENBERG, LOLLI and RUBIN 1942, LOLLI and RUBIN 1943, 1943). MAYER suggested intermittent obstructions to absorption produced by the autonomous nervous system and

vasomotor reactions as being primarily responsible, to which also ELBEL (1956) refers.

In order to find support for the contention that the retarding effect of alcohol upon the evacuation of the stomach is not merely due to local irritation of the mucous membrane but rather to a central effect, TENNENT has performed animal experiments in which the animals were given alcohol intraperitoneally. The absorption of glucose was found to be slightly delayed at moderate and greatly delayed at strong intoxication. The said author attributed the retarded absorption to centrally delayed evacuation of the stomach caused by the resulting pylorospasm.

Criticizing TENNENT's method, GREENBERG, LOLLI and RUBIN administered alcohol intravenously to animals and found this to retard the evacuation of the stomach; they concluded that a central stimulus effect is involved.

Experiments performed with various pharmaca (e.g., benzedrine, paredrine, adrenaline, atropine, eupaverine, doryl) have further led to inferences with regard to the absorption process of alcohol from the gastro-intestinal canal (e.g., MAYER 1936, RINKEL and MEYERSON 1941, ELBEL 1956).

Most of the investigations relating directly to the motility and evacuation of the stomach have been made in animal experiments, the results of which are as such generalizable to man only with the greatest reservations (cf. e.g. ELBEL 1956). This is mainly due to the lack of suitable means of observation and recording. Some investigators (HANEBORG 1921, BERGGREN et al. 1940, HAGGARD et al. 1941) have used a stomach tube in their investigations on absorption with human subjects; this may also be responsible for the fact that the experimental population has remained rather small. HAGGARD et al. (1941) examined the rate of absorption of different beverages on four experimental subjects by introducing a Levin tube in their stomach. Although it is possible in this way to establish objectively the time when the alcohol concentration has achieved equal height in the blood and in the stomach, which can be considered to indicate completed absorption, this procedure is rather inconvenient, and unpleasant to the subject, thus possibly involving considerable sources of artificial errors. GOLDBERG (1951) has stated that BJERVER and GOLDBERG continue their investigations concerning the rate of evacuation of the stomach using distilled and brewed beverages.[1])

[1]) According to a personal communication from GOLDBERG in 1956, these investigations have not been completed.

FRANZEN (1928) has used an x-ray method to determine the evacuation of sherry solutions from the stomach, the evacuation being observed at regular intervals on control days and on days of experiment. An x-ray method was also employed by BICKEL and FLEISCHER (1930, 1931), who showed the delaying effect of a brewed beverage on the evacuation of the stomach; this effect varies according to the quality of the beer.

Since thus alcohol particularly in strong concentrations has been found in numerous investigations to delay the evacuation of the stomach and, on the other hand, brewed beverages have been shown to act in a similar manner, a comparison of the beverages in regard to this effect is indicated, but no adequate investigation of this kind is known to the author.

42. METHOD

In the present investigation an x-ray method has been employed, which can be considered adequate from a point of view of the problem under consideration.

The experiments of the B series comprise ten subjects in all. Their ages and weights are given in Table 26 in the Appendix.

All the experimental subjects were moderate users of alcohol. Heavy drinkers were not accepted since such persons display a more rapid absorption of alcohol (SCHWEISHEIMER 1913, BERNHARD and GOLDBERG 1935, SCHMIDT 1937, GOLDBERG 1943). Also people suffering from any disorder of the stomach, e.g. gastritis or gastric ulcer, were excluded since these, too, show an inclination to more rapid absorption of alcohol (HANEBORG 1921, BERGGREN and GOLDBERG 1940; cf. BERNHARD and GOLDBERG 1935).

421. THE EXPERIMENTAL BEVERAGES AND THEIR DOSAGE

The dosage of alcohol in this experiment was again 1 g of absolute alcohol per 1 kg body weight ingested as brandy and as beer. The alcohol was ingested under control at regular intervals within one hour from the start of the experiment, the last dose being taken at 50 minutes.

Similarly as in the other series, the length of the fast was six hours before the ingestion of alcohol.

422. ROENTGENOLOGICAL EXAMINATION

A control examination was at first performed on each subject on an alcohol-free day. This examination took place at three points of time with half-hour intervals, enabling the motility of the stomach, its evacuation and the pyloric mechanism to be studied without the influence of alcohol. In the alcohol experiment proper, the roentgenological examination was performed at 60, 90 and 120 minutes, immediately after the taking of the blood sample. A strict timetable was followed.

The interval between alcohol experiments on the same subjects varied from two to twelve days.

Originally, the intention was to examine the same subjects also using an alcohol solution of a concentration corresponding to that of the beer. However, only three subjects could be induced to participate in any further experiments. No adequate comparison of the motility of the stomach and the absorption could thus be made between beer and an alcohol solution of equivalent concentration. The individual observations on these three subjects are presented later.

423. BLOOD ALCOHOL DETERMINATIONS

The blood sample at 60 minutes was drawn from venous blood immediately before the first roentgenological examination. This blood alcohol figure can thus be considered fully reliable in regard to the inferences which are drawn from the blood alcohol. On the other hand some doubt may attach to the figures obtained later on, since the stomach then contained contrast medium. This potential source of error is the same in both series, but the possibility of its different effect upon the absorption of brandy and of beer cannot be excluded.

One subject (No. 10) had taken alcohol some hours before the experiment with blended brandy, and this became known only after commencement of the experiment. His results were therefore disregarded in the comparison of the blood alcohol figures.

43. ROENTGENOLOGICAL OBSERVATIONS

The roentgenological examinations were made under supervision of the roentgenologist of the Institute of Occupational Health, Dr. Antero Voutilainen, who has given a detailed report on all examinations.

60 g of micropaque Barium contrast mixed with water (ad

200 ml) was used as a contrast medium. Pressing or rubbing the stomach was carefully avoided, since this is known to increase the rate of absorption (CORI et al. 1930, HAGGARD et al. 1941, LOLLI et al. 1943).

431. X-RAY REPORTS

The roentgenologist has given the following reports concerning the motility of the stomach of the experimental subjects. In the roentgenologist's reports the time notations »at the beginning of the investigation», »after half an hour» and »after one hour» refer to the times 60, 90 and 120 minutes, respectively, since the commencement of alcohol administration (cf. p. 97, 98).

Subject No. 1.

A. Normal stomach. — The stomach is of normal size. Its walls are not dilated. The pylorus opens normally and the bulb fills regularly already at the beginning of the investigation. Evacuation starts immediately and the stomach is completely empty after half an hour.

B. Brandy exp. — The stomach is of normal size. In the pylorus a slight spasm is observable, but the bulb fills fairly well. The stomach begins to evacuate immediately at the beginning of the experiment. After half an hour a small amount of contrast medium is left in the stomach and after one hour the stomach is quite empty.

C. Beer exp. — The stomach is bigger than normal, its walls dilated, bag-like. The walls are soft. Peristalsis passes through the stomach. A spasm can be observed in the pylorus and prepylorus immediately at the beginning of the investigation, and the bulb fills very incompletely. Only the medial recess is somewhat filled. After half an hour the bulb is filled and appears normal, but hardly any evacuation of the stomach from its original state has taken place as yet. One hour after the ingestion of the contrast medium about 1/5 of it can still be observed in the stomach, but the pylorus shows only slight spasticity.

D. Alcohol solution exp. — Stomach again bigger than normal, dilated, with some spasticity in the pylorus. The bulb is filling fairly well already at the beginning of the investigation. However, after half an hour most of the contrast medium still remains in the stomach, only about 1/4 of it has been evacuated, and after one hour still about 1/8 of it is left in the stomach.

Subject No. 2.

A. Normal stomach. — The stomach is of usual size and hook-shaped. The walls are soft. Peristalsis is normal. The pylorus opens up normally and the bulb fills regularly immediately at the beginning of the investigation. The evacuation is rapid. After half an hour the stomach is already quite empty.

B. Brandy exp. — The stomach is somewhat bigger than in the previous examination. A slight spasm is observable at the beginning of the investigation, but soon the bulb fills regularly. The evacuation of the stomach is rapid. After half an hour only very little of the contrast medium is left in the mucosa. After one hour the stomach is quite empty.

C. Beer exp. — The stomach is greatly dilated and contains plenty of liquid. Its walls are soft. The pylorus is completely closed and the bulb does not fill at all. still after half an hour the pylorus is found to be spastic and the bulb is filling in-

completely, and only a little of the contrast medium has passed into the small intestine, about 5/6 still being left in the stomach. The x-ray taken after one hour shows still about 3/4 of the contrast medium in the stomach. The pylorus is still slightly spastic, but the bulb fills already and appears regular. After one further hour about 1/4 of the original contrast medium quantity is observed in the stomach. The evacuation has thus been delayed in this experiment most markedly of all.

D. Alcohol solution exp. — The stomach is greatly dilated and contains liquid. The walls are soft. Peristalsis passes through the stomach. The pylorus is spastic. The prepyloric part, too, is slightly spastic, and the bulb is not filling at all at the beginning of the investigation. In the x-ray taken after half an hour, the prepyloric part is still found to be spastic, but the bulb has been filled and appears normal. About 1/2 of the contrast medium is still left in the stomach. In the x-ray taken after one hour, spasm can still be observed in the pylorus and about 1/4 of the contrast medium is left in the stomach. The evacuation is thus delayed.

Subject No. 3.

A. Normal stomach. — The stomach is of normal size and hook-shaped. The upper part of the mucous membrane is rough. The walls of the stomach are soft and peristalsis passes well through the stomach. The pylorus opens up normally, and the bulb fills completely regularly and is evacuated in the usual manner. After half an hour about 1/6 of the contrast medium is left in the stomach, and in the x-ray taken after one hour quite a little of it is left in the canalis region. The evacuation of the stomach is quite normal.

B. Brandy exp. — The stomach is of the same size and shape as previously. Peristalsis is normal. The pylorus opens up normally and the bulb fills regularly already at the beginning of the investigation. The stomach is evacuated in the usual manner. After half an hour about 1/5 and after one hour about 1/6 of the contrast medium is still left. The passage of the contrast medium is quite normal.

C. Beer exp. — The stomach is markedly dilated, containing liquid in the corpus canal. The prepyloric part is spastic, and the bulb is filling incompletely, i.e., not quite regularly. The evacuation is clearly delayed. After half an hour about 3/4 of the contrast medium are still left in the stomach, and after one hour still about 1/2 of its original amount. In all x-rays a slight spasticity is found in the prepyloric part, although least of all in the x-ray taken after one hour. Evacuation is clearly delayed in comparison to the preceding experiments.

Subject No. 4.

A. Normal stomach. — The stomach is of normal size and shape, and hook-shaped. The relief of the mucous membrane is rough. The walls are soft and yielding and the peristalsis is lively. The pylorus opens up normally, and the bulb fills regularly and empties without obstruction. After half an hour about 1/3 of the contrast medium is left in the stomach, and after one hour about 1/5 of its original amount.

B. Brandy exp. — The stomach is of the same size as before. The walls are soft. The pylorus opens up normally, and the bulb fills regularly. After half an hour and after one hour nearly the same amount of contrast medium is left in the stomach as in the preceding investigation.

C. Beer exp. — The stomach is greatly dilated in comparison with the preceding investigations and contains liquid. The pylorus is spastic and has not opened at all, and the bulb is not filling at the beginning of the investigation. In the x-ray taken after half an hour still about 1/2 of the contrast medium is found to be left in the stomach. The pylorus has opened up and the bulb already fills regularly. In the x-ray taken after one hour still at least 1/3 of the contrast medium is found to be left in the stomach. The evacuation is thus clearly delayed in comparison with the preceding investigations.

Subject No. 5.

A. Normal stomach. — The stomach is of ordinary size and hook-shaped. The walls are soft. Peristalsis is normal. The pylorus opens up normally and the bulb at once fills regularly, and empties without obstruction. After half an hour still about 1/4 of the contrast medium is left in the stomach, and after one hour about 1/7.

B. Brandy exp. — The stomach is of ordinary size as before, hook-shaped. Peristalsis lively. The bulb fills regularly and also empties rapidly. No spasm can be observed, and after half an hour the stomach is quite empty.

C. Beer exp. — The stomach is greatly dilated in comparison with the preceding investigations and contains liquid. The pylorus is spastic and the bulb fills incompletely, spastically, and is somewhat deformed. Still after half an hour spasticity is observed in the pylorus, and the bulb does not appear quite regular. The x-rays taken after one hour also show a slight spasm. After half an hour about 1/4 of the contrast medium is left in the stomach, and in the x-ray taken after one hour nearly the same amount. Evacuation is thus delayed.

Subject No. 6.

A. Normal stomach. — The stomach is bigger than normal, somewhat pendulous, and hook-shaped. The relief of the mucous membrane is slightly rough. The walls are soft. Peristalsis passes well through the stomach. The pylorus opens up normally and the bulb fills regularly already at the beginning of the investigation. Its evacuation is normal. After half an hour still about 1/4 of the contrast medium is left in the stomach, and after one hour approximately the same amount. The stomach has thus not been evacuated completely.

B. Brandy exp. — As before, the stomach is bigger than normal, and hook-shaped, but not bigger than in the preceding investigation. Peristalsis passes regularly through the stomach. The pylorus opens up normally. The bulb fills regularly and empties without obstruction. After half an hour about 1/6 of the contrast medium is left in the stomach, i.e., less than in the normal stomach at this stage. In the x-ray taken after one hour even less contrast medium is observed. The evacuation is somewhat accelerated in comparison with the normal stomach.

C. Beer exp. — The stomach is greatly dilated and contains liquid. Spasticity can be observed in the prepyloric part of the stomach, yet the bulb fills fairly regularly, though not as completely as in the previous x-rays. After half an hour still about 1/4 of the contrast medium is left in the stomach, and after one hour 1/5. Evacuation of the stomach is delayed, particularly in comparison with the brandy experiment.

Subject No. 7.

A. Normal stomach. — The stomach is of normal size and hook-shaped. The relief of the mucous membrane is rough. The walls are soft, and peristalsis is normal. In the pyloric part of the stomach a slight spasm is observed, but the bulb is filling already at the beginning of the investigation, although it does not appear quite regular, i.e., the bulb, too, is slightly spastic. After half an hour about 1/3 of the contrast medium is found to be left in the stomach, and the bulb fills fairly regularly. After one hour about 1/4 of the contrast medium is still left in the stomach, and the bulb is regular.

B. Brandy exp. — The stomach is of usual size as before, and the relief of the mucous membrane is rough. In the pylorus and the prepylorus a slight spasm is observed, which is similar to that in the preceding investigation. The bulb is filling somewhat spastically, though fairly regularly already at the beginning of the investigation. Affer half an hour about 1/4 of the contrast medium is left in the stomach, and the bulb is already filling regularly. After one hour still about 1/6 of the contrast medium is left. The stomach seems to have been evacuated more rapidly than normal in this investigation.

C. Beer exp. — The stomach is greatly dilated and contains liquid. The pylorus is completely spastic, and not even a sign of its opening is observed at the beginning or the investigation. The x-ray taken after half an hour shows that the pylorus has

already opened up a little, but it is still markedly spastic, and the bulb is filling very incompletely, and only a little of the contrast medium has passed into the small intestine. In the x-ray taken after one hour, spasticity is still observed in the pylorus, and the stomach has emptied only about 1/4 of the original amount, i.e., 3/4 of the contrast medium are still left in the stomach. The bulb appears regular. Evacuation is thus greatly delayed as compared to the preceding investigations.

Subject No. 8.

A. Normal stomach. — The stomach is of normal size and hook-shaped. The walls are soft, persistalsis is lively and deep. The pylorus has not opened up at the beginning of the investigation, and the bulb does not fill, so spasm must be present in the pylorus. After half an hour the bulb is filling completely regularly and empties without obstruction. After half an hour about 1/2 of the contrast medium is left in the stomach, and after one hour still about 1/4 of its original amount.

B. Brandy exp. — The stomach is somewhat bigger than before. Peristalsis is lively even now. At the beginning of the investigation the pylorus is spastic and the bulb does not fill at all. In the x-ray taken after half an hour the pylorus is already found to have opened up and the bulb is filling, but it is still spastic and not quite regular. The stomach contains about 5/6 of the original amount of contrast medium, and contrast medium is otherwise found only in the duodenum. In the x-ray taken after one hour the bulb is found to be regular, but about 3/4 of the original amount of the contrast material are still left in the stomach. The evacuation of the stomach is thus clearly delayed as compared to normal.

C. Beer exp. — The stomach is found to be dilated and markedly bigger than in the preceding x-rays, and plenty of liquid is seen in the stomach. Spasm is observed in the pylorus, but the bulb already contains contrast medium and it is filling, though not yet quite completely. After half an hour the contrast medium has been evacuated and it is observed in the stomach at about 1/3 of the original amount. After one hour the amount of contrast medium is nearly the same, and at this stage the evacuation of the stomach is now delayed and the pylorus appears spastic in all x-rays.

Subject No. 9.

A. Normal stomach. — The stomach is of normal size and hook-shaped. The relief of the mucous membrane is somewhat rough. No secretion in the stomach. The walls are soft. Peristalsis is normal. The pylorus opens up normally and the bulb fills at once regularly and empties without obstruction. After half an hour only a very small amount of contrast medium is left in the stomach and after one hour it is nearly empty.

B. Brandy exp. — Compared to the preceding investigation the stomach is somewhat larger, pendulous, and contains some secretion. Even now the pylorus opens up regularly, the bulb is filling regularly and the stomach empties rapidly. No actual prepyloric spasm can be observed.

C. Beer exp. — In this investigation the stomach is found to be dilated and it contains plenty of liquid. A prepyloric spasm is observable; the pylorus does not open at the beginning of the investigation and the bulb does not fill completely. After half an hour the pylorus has opened up, and the bulb has filled regularly; about 1/4 of the original amount of the contrast medium is left in the stomach. Still after one hour about 1/6 of the contrast medium is left. The stomach has thus not been completely evacuated.

D. Alcohol solution exp. — The stomach is dilated and plenty of liquid is observed in the stomach in addition to the contrast medium. The prepyloric part is spastic at the beginning of the investigation and the bulb does not yet fill completely at this stage of the investigation, but after about half an hour it is already completely filled and appears regular. After half an hour about 1/3 of the original amount of contrast material is left in the stomach, and after one hour still about 1/4.

Subject No. 10.

A. Normal stomach. — The stomach is of medium size and hook-shaped. The relief of the mucous membrane is rough and the contrast medium adheres to its irregularities. The walls are soft. Peristalsis is normal. The pylorus opens up normally already at the beginning of the investigation and the bulb is filling regularly. After half an hour about 1/5 of the original amount of the contrast medium is left and after one hour nearly the same amount. Evacuation of the stomach is normal.

B. Brandy exp. — The stomach is of normal medium size, as was the case in the normal stomach. Its walls are soft. The relief of the mucous membrane is rough throughout, and irregular. The pylorus opens up normally already at the beginning of the investigation and the bulb is at once filling regularly. After half an hour only a little of the contrast medium is left in the stomach in the canalis region, and after one hour it has almost completely disappeared. The evacuation of the stomach is more rapid than in the investigation of the normal stomach.

C. Beer exp. — The stomach is clearly dilated and contains plenty of liquid. In the first x-ray not much peristalsis can be observed. The pyloric part is completely spastic in this investigation and the bulb does not fill at all. In the x-ray taken after half an hour it is seen that at least 1/2 of the original amount of the contrast medium still remains in the stomach; the pylorus has opened and the bulb is filling regularly. In the x-ray taken after one hour about 1/3 of the contrast medium is left and the bulb continues to fill regularly. The evacuation of the stomach is delayed as compared to the investigation of the normal stomach.

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432. CONDENSED ROENTGENOLOGICAL FINDINGS

In the following the roentgenological observations on the motility of the stomach will be discussed in four different groups, particular attention being centred on four main points. The individual roentgenological observations stated in the foregoing can be condensed into the following comparative results:

Pylorospasm

Control vs. brandy exp.	6 cases, no pylorospasm in either experiment
	2 » , some spasticity in the brandy experiment
	2 » , slight spasticity in both experiments
Control vs. beer exp.	10 cases, stronger spasticity in the beer experiment
Brandy vs. beer exp.	9 cases, stronger spasticity in the beer experiment.
	1 case, stronger spasticity at the beginning of the brandy experiment

It can be seen from this that brandy seems to have caused only a very slight and uncertain pylorospasm. By contrast, beer seems to have produced in nine cases more marked spasticity of the pylorus than could be observed either in the brandy or the control experiment.

Filling of the bulb

Control vs. brandy exp.	8 cases, no difference
	2 » , filling more incomplete at the beginning of the brandy experiment
Control vs. beer exp.	4 cases, filling more incomplete in the beer experiment
	6 » , filling markedly incomplete in the beer experiment
Brandy vs. beer exp.	9 cases, filling more incomplete in the beer experiment
	1 case, filling more incomplete at the beginning of the brandy experiment

It can be noted from this that the filling of the bulb is more incomplete in nine cases in the beer experiment than in the brandy and the control experiments.

Evacuation of the stomach

Control vs. brandy exp.	4 cases, evacuation more rapid in the brandy experiment
	1 case, evacuation slower in the brandy experiment
	5 cases, no difference observable.
Control vs. beer exp.	10 cases, evacuation slower in the beer experiment
Brandy vs. beer exp.	9 cases, evacuation slower in the beer experiment
	1 case, evacuation slower in the brandy experiment

It can be stated that in the beer experiment the evacuation has been slower than normal in ten cases, and in nine cases slower than in the brandy experiment.

The amount of contrast medium left in the stomach on an average in the later stages of the experiment was clearly greater in the beer than in the control and brandy experiments.

44. BLOOD ALCOHOL

Table 25 gives the mean values of the blood alcohol and their ranges. It can be noted that in the brandy series the mean of the differences (brandy series minus beer series), 0.3 per mil, is significant at 60 minutes. At 90 and 120 minutes no significant differences appear, but at 180 minutes the difference again is significant; it is now negative, —0.14 per mil. In agreement with previous results the blood alcohol at 60 minutes is higher by about 40 per cent in the brandy than in the beer experiment. Each invidual blood alcohol figure found at 60 minutes in the brandy experiment is higher than the blood alcohol of the same subject at 60 minutes in the beer experiment.

TABLE 25. *Blood alcohol, per mil, in the experiments relating to the motility of the stomach (B series)*

	Time, minutes since commencement of ingestion				
	0	60	90	120	180
	Brandy experiments				
Mean	0.10	1.17	1.12	1.03	0.80
Lowest	0.02	0.72	0.67	0.66	0.39
Highest	0.56	1.91	1.72	1.66	0.96
	Beer experiments				
Mean	0.04	0.77	0.98	1.00	0.94
Lowest	0.02	0.50	0.74	0.72	0.61
Highest	0.06	1.11	1.26	1.24	1.09

Figure 18 shows the mean blood alcohol curves from this study.

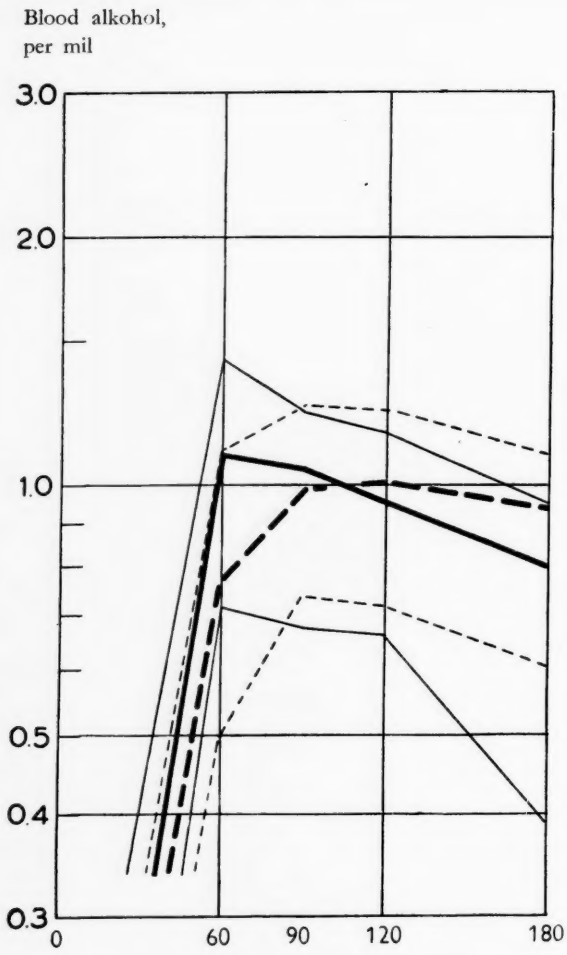

FIG. 18. *Blood alcohol values in the brandy and beer experiments of the study relating to the motility of the stomach, B series.*

——— *Brandy experiments, mean values*
» » *highest and lowest*
– – – – – *Beer experiments, mean values*
» » *highest and lowest*

45. EXPERIMENTS WITH ALCOHOL SOLUTION

With three subjects (No. 1, 2, and 9) of the series under discussion a corresponding investigation was made, using an aqueous solution of alcohol of 3.6 per cent by weight. According to the roentgenologist's report, the alcohol solution was

evacuated from the stomach obviously more rapidly than beer in cases No. 1 and 2. By contrast, the evacuation of beer seemed to be more rapid in case No. 9 than that of the alcohol solution.

46. SYNOPSIS

The findings from the experiments on the motility of the stomach and on the absorption can be summarized as follows:

The pylorus is spastic particularly in the beer experiments. Compared to the brandy experiments, the pylorus was more spastic in nine out of ten cases.

The most important fact established in these experiments is that the evacuation of the stomach was slower in the beer experiment than in the brandy experiment in nine cases out of ten, and it was slower in the beer experiment than in the control experiment in all ten cases.

In four cases out of ten, evacuation was more rapid in the brandy experiment than in the control experiment. In five cases no difference was observable between the brandy and the control experiments.

Whether the delayed evacuation in the beer experiments is attributable to pylorospasm indeed or to some other changes in the motility of the stomach, cannot be stated with certainty on the basis of the present observations. The pylorospasm can be considered an indication of the different reaction of the stomach caused by beer, as compared with brandy, without immediately constituting the factor responsible for the delayed evacuation of the stomach (cf. p. 129). However, in view of the remarkable strength and persistence of the pylorospasm in the beer experiments the impression cannot be avoided that it may be essentially involved in the slow passage of the beverage into the intestine.

In good agreement with the findings relating to the motility of the stomach, the blood alcohol at 60 minutes was higher in the brandy experiment than in the beer experiment, the mean difference being 0.3 per mil ($P = 0.01$). In every individual case the blood alcohol figure was higher in the brandy experiment at 60 minutes than in the beer experiment. At 90 and 120 minutes no significant differences were observable, but at 180 minutes the blood alcohol was higher in the beer experiment. It should be noted that the determinations made at times later than 60

Subject No. 3

Subject No. 5

Normal stomach

Brandy experiment,
60 minutes after commencement of ingestion

Beer experiment,
60 minutes after commencement of ingestion

FIG. 19. *Some typical x-rays taken in the experiments relating to the motility of the stomach.*
The spastic pylorus and delayed evacuation in the beer experiments can be clearly seen.

Subject No. 10

minutes cannot be regarded as quite reliable since the stomach contained contrast medium, which may have had a different effect upon the absorption of beer and of brandy.

The x-rays taken of three subjects at 60 minutes in the control, brandy and beer experiments, which have been selected by the roentgenologist as representative of the behaviour of the stomach, are reproduced in Figure 19.

5. DISCUSSION

51. THE EXPERIMENTAL BEVERAGES

On the basis of the earlier findings mentioned in the literature review as well as the experimental results of some other authors it appears necessary to pay closer attention to the qualitative and quantitative properties of the beverages used in this investigation without entering upon any exhaustive systematic survey, but rather concentrating on such matters which can be primarily assumed to carry significance in relation to the present investigation.

511. ALCOHOL CONTENT

In consequence of the greatly different alcohol concentrations of the brandy and of the beer (32.6 and 3.6 per cent by weight, respectively), the diffusion pressure of alcohol in the gastro-intestinal canal will be higher in the brandy than in the beer experiments. As the absorption of alcohol mainly obeys the laws of diffusion (BERGGREN and GOLDBERG 1940, etc.), a more rapid increase of the blood alcohol in the brandy experiments is to be expected. It is true that some investigators have noted a slower ascent of the blood alcohol curve with stronger than with weaker beverages (TUOVINEN 1930, HAGGARD, GREENBERG and LOLLI 1941), but in these investigations the concentration of the strong alcohol solution has been comparatively high (40—60 per cent), which may also cause delayed evacuation of the stomach (e.g. CORI, VILLIAUME and CORI 1930).

In the investigations of LOLLI and RUBIN (1943), with beverages of 45, 30, 15 and 5 per cent (by volume), the optimum concentration with regard to the rate of absorption was 30 per cent, although its manifestation depended on the total dosis administered (cf.

MELLANBY 1919). The alcohol concentration of the brandy used in the present investigation is in fact not very far from this concentration established as optimum by LOLLI and RUBIN.

Since, however, the experimental results generally show a certain dispersion, it is evident that the alcohol concentration of the beverage is not as decisive for the rate of absorption as has been claimed as a rule; a fact which several investigators have pointed out (SCHMIDT 1937, JUST 1952, etc.).

512. CARBOHYDRATES, PROTEINS, VITAMINS AND OTHER CONGENERS

In the brandy experiments the various other ingredients of the beverage are not likely to have any great significance. The concentration of sugar in the brandy is 0.1 per cent, which can be completely neglected as insignificant. Similarly the quantity of French brandy and of its congeners in the brandy is rather small (not more closely stated), and it has to be left out of account as well.

The beer which was used in this investigation contains about 3 per cent of carbohydrates, namely, maltose and polysaccharides (dextrins; cf. KRAUSE 1935), i.e., altogether about 50—65 g in the quantities used in each beer experiment. These carbohydrates, which are undoubtedly significant in regard to their amount, are mainly composed of glucose.

The retarding effect of food upon the absorption of alcohol has been studied by numerous investigators (WIDMARK 1916, 1933, 1934, MELLANBY 1919, HAMMARSTEN and LILJESTRAND 1922, SOUTHGATE 1925, KIONKA 1927, TUOVINEN 1930, KRIEBS 1934, SCHMIDT 1937, HAGGARD, GREENBERG and LOLLI 1941, GOLDBERG 1943, 1951, KLEIN 1949, 1951, VON ORELLI 1949, SERIANNI, CANNIZZARO and MARIANI 1950, 1953, RAUSCHKE 1952, etc.). Some of them (HAGGARD et al., GOLDBERG) have compared the absorption of the alcohol in beer to the absorption of distilled spirits ingested with food. TUOVINEN (1930) found that a mixed meal, proteins and carbohydrates indeed delay efficiently the alcohol absorption in the gastrointestinal canal. The proteins, present in the beer at about 0.3 per cent, have to be regarded as unimportant on account of their small amount.

The results obtained by GOLDBERG (1951) with Swedish beer, according to which the rate of elimination of the alcohol in brewed beverages is higher than that of the alcohol in distilled beverages, could not be reproduced by ALHA (1953) in his experiments with Finnish beverages, the elimination curves obtained by him with beer and brandy being similar to each other.

It is unlikely that the nutrients concerned in this investigation would have an accelerating effect on the alcohol metabolism. Most later investigators have abandoned the earlier opinion that glucose would have an accelerating effect on the combustion of ethyl alcohol (e.g. LOOMIS 1950, JACOBSEN 1952, SEIFERT 1955). On the other hand, the accelerating effect of fructose is more generally acknowledged (KLEIN 1952, JUST 1952, PLETSCHER 1953, BERG 1953, STUHLFAUTH 1954, etc.), but some other authors express their doubt of this statement as well (cf. ELBEL 1956). The beer used in this investigation contains at its most only traces of fructose (RAHIALA, personal communication).

Some investigators claim that the pyruvic acid appearing as an intermediate combustion product in the carbohydrate metabolism accelerates the alcohol metabolism (WESTERFELD, STOTZ and BERG 1942), but others have not been able to confirm these results (GREGORY et al. 1943, HULPIEU et al. 1948, BARTLETT and BARNET 1949).

Beer contains thiamine, riboflavin, nicotinic acid, pyridoxine and pantothenic acid, although in very small amounts according to LÜERS (1950) (hardly any of them surpassing, per litre, the order of magnitude of the daily requirement; DUNCAN 1953, JOSEPHSON 1956). It is likely, therefore, that these constituents of beer have no essential significance for the results of this investigation with regard to the combustion of alcohol and to alcohol tolerance (see e.g. JOSEPHSON 1955c, HARGER and HULPIEU 1956).

The data relating to the significance of vitamins with regard to the alcohol metabolism are still incompletely investigated (cf. e.g. JACOBSEN 1952, SEIFERT 1955, FORSANDER 1955, ELBEL 1956).

Some of the constituents of beer are as yet unsufficiently known as regards their properties and effects. For instance, this is true with regard to hops (STEPP 1954, JOSEPHSON 1955a), in which there are known to occur, among other constituents, α and β lupulinic acid (humulon and lupulon). Both stimulate the respiratory and vagus centres and diminish the activity of the cardiac muscle (SOLLMANN 1950). The hypnotic effect ascribed to beer is probably also, at least in part, attributable to the hops (STEPP, SOLLMANN, etc.).Whether the principles contained in hops mainly are also responsible for the effects of beer upon the stomach (BICKEL et al. 1929, 1930, 1931, STEPP 1954, JOSEPHSON 1956) has

not been adequately shown. All these principles are not active when administred per os (SOLLMANN).

Some other not more closely specified constituents of beer connected with the fermentation of malts have been shown to contribute to the diuretic qualities of beer (EK and JOSEPHSON 1953). According to these investigators, beer has a distinctly stronger diuretic effect than the corresponding quantity of water and a characteristic influence on the elimination of electrolytes, increasing the elimination of sodium more than water does, on the expense of the elimination of potassium. The combined amount eliminated of these two substances seems to be practically constant as calculated as the number of ions. The diuretic effect with regard to water has been verified with cardiac patients, among others, by WALLGREN (1954). The hops in beer do not seem to be responsible for this effect, which is rather connected with the malt fermentation; it has been assumed that the xanthine derivatives present in beer might possibly cause the said diuretic effect (JOSEPHSON 1956). It will have to be determined in later investigations whether such substances, too, might be connected in any significant way with the inebriation caused by beer.

513. CARBON DIOXIDE

Carbon dioxide, which has been stated to be present in the beer in an amount of 0.4 per cent (p. 26), has been shown to have an accelerating effect upon the resorption, among others, of alcohol (EDKINS and MURRAY 1924, see also JOSEPHSON 1955a), and similarly on the rate of evacuation of the stomach (GREENBERG and TURNER 1955).

514. WATER QUANTITY

The quantity of water contained in the experimental beverages used in this investigation has been greatly different, their concentrations having a ratio of about 1:9. In the brandy experiment the amount of water ingested cannot have been of any particular importance, but in the beer experiment it has probably been quite a noteworthy factor.

In the A_1 series, for instance, the beer quantity has been 1700—2200 ml, and the amount of water ingested has obviously an influence on the results of the experiments in many ways.

In addition to its effect of decreasing the diffusion pressure of the alcohol, the large water quantity in the beer has no doubt produced an effect in many other ways as well.

Dilatation irritation of the stomach is known to cause, by a reflectory mechanism, changes in the motility of the stomach, thus accelerating the evacuation (HUNT and SPURRELL 1951). On the other hand, large amounts of liquid have been stated to cause pylorospasm (e.g. GOLDBERG 1951). The close connection between emotional factors and motility of the stomach is well-known (e.g. WITTKOWER 1931, WOLF and WOLFF 1943, DUNBAR 1954, WRIGHT 1955). It is possible that the forced ingestion of large quantities of liquid or of a repulsive experimental beverage is associated with emotional factors which may cause changes in the motility of the stomach. It is known that repletion of the stomach can also produce reflectory changes in the cardio-circulatory functions, which may appear, e.g., as changes of pulse rate, etc. (ROEMHELD 1926, JIMENEZ-DIAZ 1931).

Among other things, the ingestion of large quantities of water causes dilution of the blood plasma and a slight decrease of its crystalloid osmotic pressure; these effects cause, by means of the osmoreceptors (VERNEY 1948), inhibition of the secretion of antidiuretic hormone (ADH).

Alcohol, too, causes a decrease in the secretion of antidiuretic hormone (SCHROEDER 1951). In their experiments with repeated alcohol doses, however, VAN DYKE and AMES (1951) found a progressively decreasing diuretic effect; they arrived at the conclusion that alcohol alone was not sufficient to prevent the secretion of antidiuretic hormone; on the contrary, adequate secretion of the hormone could be present and continue in spite of even a high blood alcohol concentration.

The probably different ADH secretion in the brandy and beer experiments might possibly be associated even with other differing physiological effects than merely those relating to diuresis.

It can be noted that the amount of liquid in experimental beverages with high water content is a factor or greatly variegated influence which can obviously affect the experimental results in numerous ways. However, the greatest importance probably attaches to the circumstance that varying water quantities associated with the experimental beverages affect the absorption and diffusion of alcohol in different ways. The distribution of the alcohol in the organism follows the quantity of water contained in each type of tissue. In this connection also the amount of water in diffusion contact in the gastro-intestinal canal, its absorption and its elimination have to be taken into account.

515. ON ELECTROLYTES AND HYPOTONICITY

The low sodium concentration of beer (Na_2O = 1.7—2.3 per cent, K_2O = 32.8—38.2 per cent; HAJEK, rev. by LÜERS) is a factor worthy of notice (cf. OLMSTEAD, CASSIDY and MURPHY 1954, JOSEPHSON 1955, 1956).

The hypotonicity of the beverage may also delay the evacuation of the stomach (HOUSSAY 1955), and the scantiness of sodium has also to be mentioned as a dynamic factor of influence upon the diuresis caused by beer. Disturbances of electrolyte and water balance are known to have a causative relation with disorders of the nervous functions (HOLMES and TOWER 1955, BAKER 1955, BLAND 1956; cf. also HAGGARD et al. 1950). However, the changes of this kind which may result from the test beverages used in the present investigation are obviously so small that they cannot be essentially responsible for our results, if the buffer capacity of the beverages is left out of consideration (cf. JOSEPHSON 1955 b).

516. pH AND BUFFER CAPACITY

Since the earlier literature contains statements that the rate of passage of the beverage from the stomach into the duodenum through the pylorus is a quite important factor in regard to the absorption of alcohol and that this rate would depend on the buffer capacity of the beverage (HAGGARD, GREENBERG and COHEN 1938, NEWMAN and ABRAMSSON 1942), the buffer capacity of the beverages (brandy and beer) used in this investigation has been determined[1]).

Both the brandy and the beer have pH 4.7 at 25 °C. The buffer capacity is defined as $P = \frac{dB}{d\,pH}$, where B is the base concentration. During the passage from the stomach into the duodenum the pH value increases, and for this reason the buffer capacity has been determined at several pH values, the results being shown in the following table:

pH	5	6	7	8	9
Brandy, P	9.0	5.5	2.2	2.2	2.7×10^{-4}
Beer, P	0.86	1.9	2.4	0.81	1.7×10^{-2}

It can be seen that the buffer capacity of the beer indeed differs greatly from that of the brandy. For instance, at pH 7 the buffer capacity of the beer is about 100 times that of the brandy. Con-

[1]) The buffer capacities have been determined by Dr. techn. Pekka Kivalo, Finland Institute of Technology, to whom I am indebted for this help.

sidering the fact that the total amount of beer was nine times that of the total amount of brandy ingested, the buffer capacity ratio will in effect be multiplied by nine. The potential significance of the buffer capacity will be discussed further in a later part of this work.

52. NERVOUS DISTURBANCES AND BLOOD ALCOHOL

One of the possible ways to obtain a comparison between the effects of different beverages is to study whether any difference exists in regard to the relation between the observed symptoms of intoxication and the blood alcohol values. Attention could then be paid to the different phases of the blood alcohol curve such as, for instance, the appearance and disappearance thresholds, i.e., the blood alcohol values at which the symptom of intoxication becomes manifest or disappears; one might investigate the potential correlation between the rate of increase of blood alcohol and of the development of intoxication symptoms, or the main attention could be centered on the relation between blood alcohol and symptoms during the decrease of blood alcohol.

Any such particular study requires that the recording method be originally designed to suit the purpose. In order to determine the threshold values, for instance, recordings would have to be made at rather short intervals around the expected points of time or in certain phases of the blood alcohol curve. In a study of the relation between the rate of increase of blood alcohol and the development of symptoms more than one recording will have to be made during the ascent proper of the blood alcohol curve. In the present work the relation between symptoms and blood alcohol did not constitute one of the actual aims of investigation. However, it is thought worth while to consider the obtained results from this point of view as well.

Several investigators have presented tables, based on clinical observations, and on traffic accident and traffic offence statistics, on the relations between the blood alcohol and the manifestation of intoxication (Widmark 1932, Hindmarsch and Linde 1935, Andresen 1938, 1950, Holcomb 1938, Smith and Popham 1951, Ponsold rev. by Just 1952, Heyse 1944, etc.). Such tables may serve as guides for practical purposes, but they are not adequate as scientific generalizations stating the relations between blood alcohol and inebriation, nor have they been intended to serve as such by the investigators, but rather as more or less orientative »rules of

thumb» (JUST) for the requirements of every-day life. The tables which have been presented are not mutually entirely comparable, the methods and conditions of investigation and the choice of the symptom variables differing greatly. More adequate information is contained in tables which take into account the phase of intoxiation (ALHA and HJELT 1955).

521. EARLIER EXPERIMENTAL RESULTS

Numerous investigators have attempted to present explicit rules concerning the relations between blood alcohol or alcohol dosage and the symptoms of intoxication. According to VERNON (1919), neuro-muscular coordination showed a linear relation to the alcohol dosis. According to GRAF (1933), the psychic functional disturbances in steering tests seemed to increase on an average in proportion with the square of the blood alcohol. Maximum psychic disturbance seemed to occur somewhat after the maximum of blood alcohol. The recovery seemed to be faster at first than the decrease of the blood alcohol, yet the initial performance level was not attained within 24 hours, although the alcohol had disappeared from the blood. The alcohol influence threshold was dependent on the type of test and on the individual qualities of the subject. The performance at one and the same blood alcohol value was found to vary, very great variations being observed at high alcohol dosage.

In his experiments with typewriting and with the »dotting machine» as well as the »distraction machine» under the influence of alcohol, EGGLETON (1941) arrived at the following conclusions: The disturbances of the central nervous system are not dependent on the blood alcohol alone but also on its rate and direction of change. The disturbance at any alcohol concentration was greater when the blood alcohol was increasing, and the functional disturbance increased at the same rate as the blood alcohol. The recovery of the nervous functions upon decrease in blood alcohol was dependent on its rate of decrease.

GOLDBERG (1943, 1951) observed a linear impairment of the functions as related to blood alcohol if the disturbance was expressed in a logarithmic scale. A similar relation has been observed by BSCHOR (1951).

The great importance of the phase of intoxication (the direction of change of the blood alcohol) in regard to the manifestation of

nervous functional disturbances is generally recognized (Mellanby 1919, Miles 1924, Tuovinen 1930, 1938, Mirsky Piker, Rosenbaum and Lederer 1941, Eggleton 1941, Newman and Abramson 1941, Goldberg 1943, Rabinowitch 1948, Bjerver and Goldberg 1950, Goldberg 1951, Bschor 1951, 1952, Alha 1951, 1953, 1956). Bschor considers the differences in strength of the symptoms of intoxication during the resorptive and postresorptive phases in the light of the investigations of Haggard et al. (1934, 1940 and 1943). The cerebral circulation plays a special part in the intoxication (see also Moniz 1940). The blood flow in the brain, which is considerably superior to that of the other organs on an average, is responsible for the fact that a considerably high alcohol supply is available to the brain in the resorptive phase before the attainment of general diffusion equilibrium, as compared with the rest of the organism. When diffusion equilibrium has obtained, the distribution of the alcohol in the organism is determined by the water content of the various organs, and a given blood alcohol figure is associated with a lower alcohol concentration in the brain at this stage than during the resorptive phase. Bschor also refers to the general principle known from biochemical regulation phenomena as well as from neurophysiology, namely, the importance of the rate of change of the reaction irritants, in this instance the rates of change of blood alcohol and brain alcohol, which might possibly cause »irritation in the protein and enzyme substances of the ganglion cells» during the resorptive phase. According to Alha (1951) the fact that the symptoms are much more marked during the ascending phase than at the same blood alcohol level during its descent is in conformity with Weber's law.

Several investigators (e.g. Graf 1933, Elbel 1937, Mirsky et al. 1941, Eggleton 1941, Newman and Abramson 1941, 1942, Goldberg 1943, MacLeod 1953, Bschor 1951) have paid attention to the so-called threshold concentration, i.e., the blood alcohol level at which a given symptom becomes manifest (appearance threshold) or disappears (disappearance threshold), or the increase in blood alcohol which produces an observable change in the investigated symptoms of intoxication. The appearance threshold is lower during the ascent of the blood alcohol curve

than the disappearance threshold during its descent (GOLDBERG 1943, BSCHOR 1951).

522. PRESENT FINDINGS

The object of this study has been a comparison between two beverages differing greatly both quantitatively and qualitatively. Also other factors than their alcohol content could be expected to affect the results, and it is therefore interesting to study the possible occurrence of differences in the relation between the symptoms caused by these beverages and the blood alcohol concentration.

It is not possible to make any calculations from the data of this investigation as to the correlation of the symptoms of inebriation and the rate of increase of the blood alcohol, owing to the circumstance that the blood alcohol as well as the said symptoms have not been recorded before the time of 60 minutes since the commencement of ingestion. For the same reason, for instance, no threshold values could be established.

With regard to swaying a correlation graph was presented, which revealed a very weak correlation between the symptoms of an individual and the blood alcohol. Figure 20 shows the correlation between the mean performances and the mean blood alcohol in the swaying test. In the brandy experiment swaying seems to be more strongly dependent on blood alcohol than in the beer experiment, where it is highly questionable, also in view of the fact that the plots represent nonsignificant changes in comparison with the mean at 0 minutes. The comparison is impeded by the circumstance that no observations exist in the brandy experiments prior to the time at which the highest blood alcohol figure has already been obtained and that thus obviously the beginning of a different phase of inebriation is concerned in the plots relating to 60 minutes in this series. This latter remark, of course, applies to the other considerations of correlation as well, which are discussed in the following. — The figure would seem to support the contention that greater disturbances as related to blood alcohol are obtained at the earliest recorded stage of intoxication.

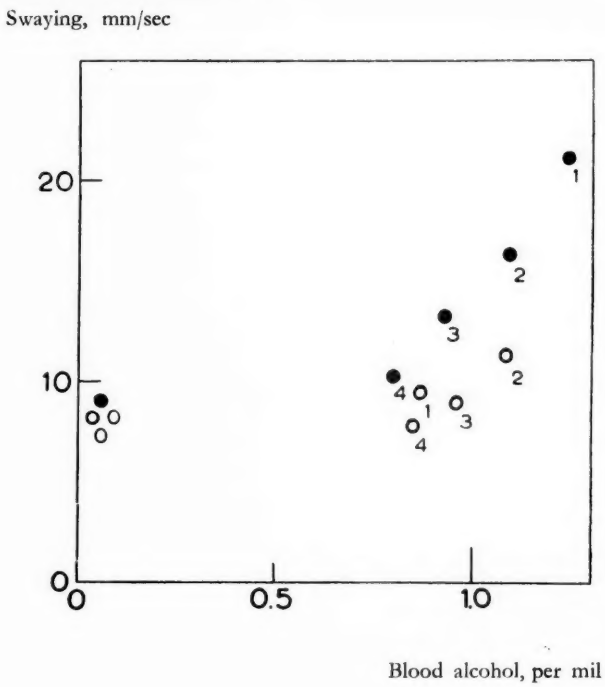

FIG. 20. *Correlation between the mean values of swaying and of blood alcohol in the brandy and beer experiments, A_1 series.*

● *Brandy experiments* ○ *Beer experiments*

1, 2, 3 and 4: 60, 90, 120 and 180 minutes since the commencement of ingestion

Since no blood samples were taken in connection with the finger-finger test of the A_2 series, no corresponding graph can be presented from this investigation. Instead, the mean correlation for manual dexterity is shown in Figure 21, for finger dexterity in Figure 22 and for intellectual performance in Figure 23 (as derived from the corrected as well as the uncorrected values).

In the brandy experiment in the manual dexterity test a certain degree of correlation seems to be present between the mean values, but not in the beer experiment.

In the finger dexterity test a tendency, although very slight and uncertain, towards a similar difference between the brandy and beer experiments can be discerned.

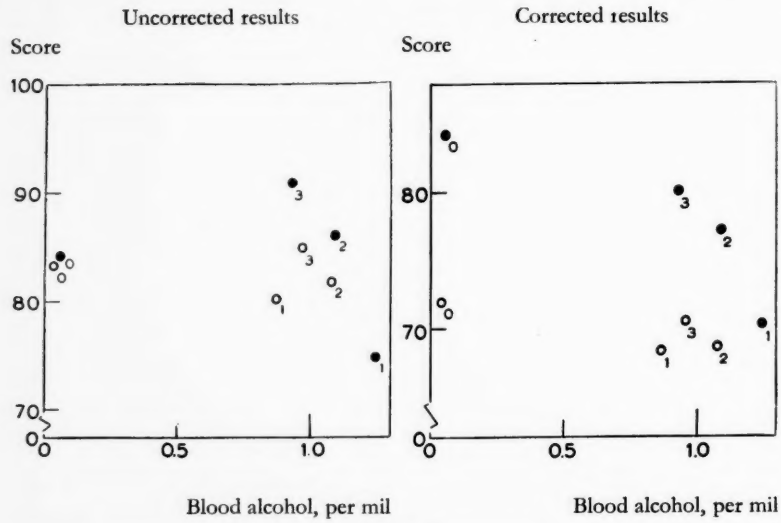

FIG. 21. *Correlation between the mean results of the manual dexterity test and blood alcohol in the brandy and beer experiments, A_1 series.*

● *Brandy experiments* ○ *Beer experiments*

1, 2, 3 and 4: 60, 90, 120 and 180 minutes since the commencement of ingestion

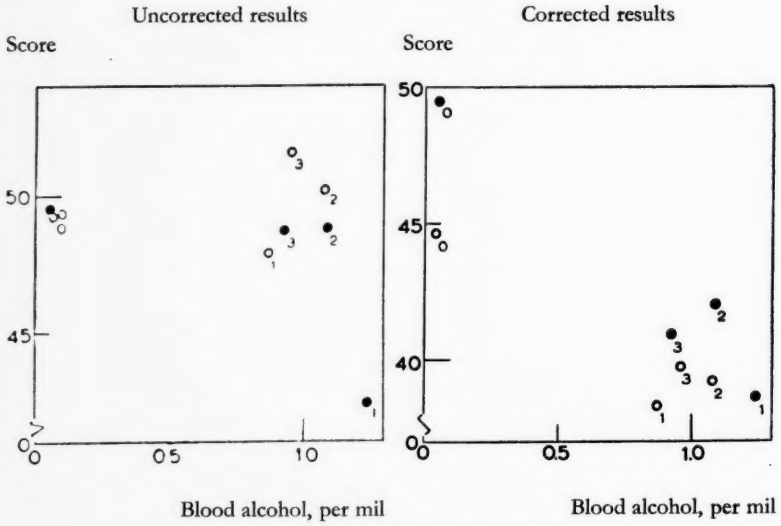

FIG. 22. *Correlation between the mean results of the finger dexterity test and blood alcoho. in the brandy and beer experiments, A_1 series.*

● *Brandy experiments* ○ *Beer experiments*

1, 2, 3 and 4: 60, 90, 120 and 180 minutes since the commencement of ingestion.

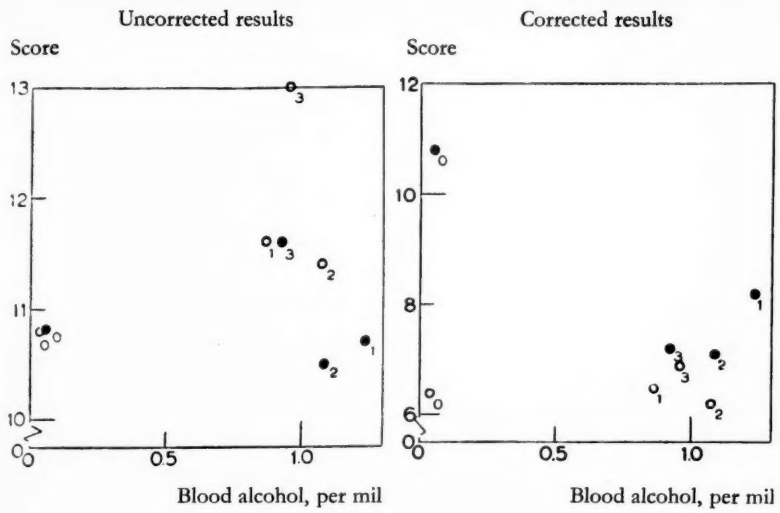

FIG. 23. *Correlation between the mean results of the square test and blood alcohol in the brandy and beer experiments, A_1 series.*

● *Brandy experiments* ○ *Beer experiments*

1, 2, 3 and 4: 60, 90, 120 and 180 minutes since the commencement of ingestion

No correlation can be said to exist between the mean values in the intellectual performances (square test).

As a synopsis, it can be concluded that a more distinct dependence of the mean values for the functional disturbances on the mean blood alcohol has been observed in this investigation in the brandy than in the beer experiments, their correlation being nearly nonexistent in the latter. In the beer experiments the functional disturbances are very slight in general, and some correlation appears only if the disturbances at some later time point are compared to the initial values.

No correlation is observable between intellectual functions and blood alcohol; the improvement seems to be greatly delayed in both series, particularly according to the corrected values, and some impairment of the performance seems to take place still at decreasing blood alcohol.

As has been mentioned before, the blood alcohol rose more rapidly in the brandy than in the beer experiments; this fact has been shown to contribute essentially to the occurrence of symp-

toms of intoxication (MIRSKY et al., EGGLETON, BSCHOR). In the beer experiments the blood alcohol maximum also remained considerably lower than in the brandy experiment, which then also applies to the alcohol concentration in the central nervous system. However, it is likely that the differences in state of intoxication between the brandy and beer experiments are not only dependent on the differences in height, and rate and direction of change, of the blood alcohol, but probably also on differences in other possible physiological effects of the beverages (cf. p. 111—116). These latter might be responsible, at least in part, for the difference, evident in some of the results (Romberg test, finger-finger test and manual dexterity), as to the rate of recovery in the brandy and the beer experiments. Similar retarding in the rate of recovery in beer experiments have been observed, e.g., by GRAF, ALHA, and also in some cases by GOLDBERG.

The results of the present investigation seem to be somewhat at variance with the general result of GOLDBERG, in that a correlation of varying strength, and sometimes nearly nonexistent, has been found in the case of different function tests and the blood alcohol in the brandy and beer series.

53. COMBINATION OF RESULTS, AND CONCLUSIONS

Some of the results of the experiments presented in the foregoing can be combined to constitute more or less consistent combined results, and some of the results obtained in this investigation can be coordinated with those of another component study of this work. Comparison with the results of other investigators is only possible in occasional instances in a certain degree.

At the same time the principal answers to the questions posed in our formulation of the problems, as furnished by the experiments described in the foregoing, are presented in the scope of this section.

531. BLOOD ALCOHOL

A comparison between the changes in blood alcohol caused by brandy of 32.6 per cent by weight and by beer of 3.6 per cent

by weight has been performed in all experiments of the present investigation, using the same alcohol dosis (equivalent to 1 g of absolute alcohol per 1 kg of body weight). The manner of administration has been strictly controlled and the same in all experiments. The experimental beverage was taken upon an empty stomach (after six hours' fast) in equal portions, according to a fixed schedule (six equally spaced portions between 0 and 60 minutes). The strong beverage has been administered in its undiluted state.

A_1 series. — In the A_1 series, in which both the neurological comparative experiments and the actual comparative investigation on the circulatory functions and on the blood alcohol were performed, the following results have been obtained: During the first hour the blood alcohol (in capillary blood) rose to a significantly higher value in the brandy than in the beer experiments, the means at 60 minutes being 1.24 and 0.87 per mil, respectively, i.e., 40 per cent higher in the brandy experiments. During the interval from 60 to 90 minutes no more increase of the blood alcohol occurred in the brandy experiments, while the rise in the beer experiments was still significant. Between 90 and 120 minutes the blood alcohol curve was still significantly ascending in the beer experiments, but in the brandy experiments it had already significantly commenced its descent. At 120 minutes the curves came together and no significant difference could be observed.

In the brandy experiments the mean blood alcohol curve had a peak between 60 and 90 minutes, in the beer experiments between 90 and 120 minutes.

In both series the incipient elimination seemed to be linear in relation to time. The experiments were discontinued at a stage too early to allow of the calculation of the so-called Widmark constant. In the intervals between 150 and 180 minutes and between 180 and 240 minutes no differences in slope of decline of the blood alcohol curves could be established.

As a special feature, a markedly wide range of variation was observed at 60 minutes in the brandy experiment; a similar observation was made at the same point of time in some neurological experiments (standing steadiness, finger-finger test, manual dexterity).

B series. — The blood alcohol (in venous blood) was also followed both in the brandy and the beer experiments in connection with the study of the motility of the stomach. A significant difference between the blood alcohol means was observed at 60 minutes; the blood alcohol was then higher by 40 per cent in the brandy than in the beer experiments (means 1.17 and 0.77 per mil, respectively), which is in very close agreement with the corresponding finding in the A_1 series. The blood alcohol figures relating to times later than 60 minutes in this series are not adequately comparable to each other since the stomach contained contrast medium, which may have affected the results.

C series. — The investigations in the C series consisted of experiments with an aqueous solution of alcohol of 3.2 per cent by weight in addition to those with beer. The total alcohol dosis was 10 per cent less than in the beer experiments since equal quantities by volume of the beverages were administered.

The blood alcohol was somewhat higher at 60 minutes in the alcohol solution experiments than in the beer experiment (means 0.77 and 0.68 per mil, respectively); at 120 minutes a slightly higher figure was noted in the beer experiments than in the alcohol solution experiments (means 1.09 and 0.99 per mil, respectively). The differences were not statistically significant, and it can be said that a similar blood alcohol level was achieved in both experiments in spite of of the different alcohol dosis, as had been intended. This finding is consistent with the results of earlier investigators (see p. 11).

Cerebrospinal fluid group. — A higher rate of increase and a higher maximum level both of the blood alcohol and the alcohol content of the cisternal liquor was observed in each case in the brandy experiments, as compared with the beer experiments. This finding, already expected in advance, is in agreement with the results relating to blood alcohol of the A_1 and B series.

The relation between the alcohol content of the cerebrospinal (cisternal) fluid both in the brandy and beer experiments is in agreement with the findings of earlier investigations: at first the cisternal fluid alcohol was closely equal to the blood alcohol figure, after which it rose to a higher level and later (in the brandy experiments) began to descend approximately in parallel with the blood alcohol curve, remaining above the latter.

Comments. — All the observations relating to blood alcohol made in this investigation are thus consistent with each other. Thus, distilled spirits produced a more rapid increase and a significantly higher level of the blood alcohol during the first one and a half hours in the brandy experiments than in the beer experiments with the same total alcohol dosis. After two hours from the start of the experiment the blood alcohol curves came together. These results with regard to rate of increase of the blood alcohol and the observed difference in its highest level are in agreement with the results obtained by MELLANBY (1919), HAMMARSTEN et al. (1922), SCHAAKE (1938), CARLSON et al. (1934), HAGGARD et al. (1941) and GOLDBERG (1951), etc. ALHA (1953) mentions that signs of slower resorption could be seen in his beer experiments. The difference between his results and those of the present investigation may, at least to a part, be accountable to the different dosage and manner of administration of the beverages (cf. p. 111, 112).

532. MOTILITY OF THE STOMACH

The experiments of the B series were instituted in view of the previous as well as the present observations that beer in particular is absorbed slowly, and because of it has been shown in earlier experiments that beer is retained for a time of marked length in the stomach (BICKEL and FLEISCHER 1931, HAGGARD et al. 1941, etc.), but that also distilled alcohol has been found to retard the evacuation of the stomach (p. 95, 111), particularly when used in strong solution, which made a comparative study necessary.

A roentgenological examination of the subjects was performed in the present investigation at 60, 90 and 120 minutes in experiments with brandy and beer in a dosage identical to that employed in the other series, the beverages being ingested between 0 and 60 minutes. Nine out of ten subjects showed a more marked pylorospasm in the beer than in the brandy experiment, and in nine cases the evacuation of the stomach was more rapid in the brandy experiment. Individual variation occured (cf. Tuovinen 1930).

Certain clinical observations made in the A_1, B and C series

may indicate a possible stronger tendency towards pylorospasm and disturbance of the evacuation of the stomach in the case of beer. No one of the subjects complained of a sensation of repletion in the epigastrium in the brandy experiments, and fewer in the water and alcohol solution experiments than in the beer experiments, the same quantity of liquid being ingested in all three last-mentioned types of experiment (see p. 92, 93).

It is difficult to state the quantitative significance of the effects of the pylorospasm and the delayed evacuation of the stomach on the course of the blood alcohol curve as compared with the other factors mentioned in the foregoing (water quantity, congeners of the beer, etc.) which may act in the same direction. It is possible that by retarding the entrance of the beer in to the duodenum, the delayed emptying restricts its contact with a more considerable diffusion surface of the gastro-intestinal canal. GOLDBERG (1951), too, has indicated this obvious explanation. The prolonged retention of the liquid in the stomach also tends to maintain a low diffusion pressure of the alcohol, since water should not be absorbed from the stomach to any noteworthy extent (cf. e.g. HOUSSAY 1955).

The original intention was to achieve a more detailed analysis of the effects of beer by means of its comparison with an alcohol solution equal in alcohol content. However, only three of the subjects from the control, brandy and beer experiments could be persuaded to participate, and no results can thus be presented in this respect. A further examination of this kind would be desirable in order to throw further light on the effect of beer upon the motility of the stomach.

No definite inferences are possible on the strength of the present investigation as to which principles present in the beer may be responsible for the delayed evacuation of the stomach and for the changes in its motility. If we consider those among the constituents and particular qualities of beer mentioned in the foregoing (p. 112—116) which may be of significance in this respect, attention has to be paid to the following: large liquid quantity (e.g. HAGGARD et al. 1941) the carbohydrates contained in beer (cf. TUOVINEN 1930, QUIGLEY 1934), the constituents of hops (BICKEL and FLEISCHER 1930, 1931), hypotonicity (e.g. HOUSSAY 1955), and acidity (e.g. BRUMMER and BUNDUL 1949, Houssay). It remains undecided in this work whether these factors take effect

by the mediation of pylorospasm, as might be inferred from earlier investigation (HAGGARD et al. 1941), or whether pylorospasm is merely an indication of changes in the motor activity of the stomach, although the present observations are not in disagreement with the first-mentioned possibility. Varying information has been given as to the factors controlling the pyloric function and it has also been stated that the function of the pylorus does not determine the evacuation of the stomach (CRIDER and THOMAS 1938, STEPP 1939, WRIGHT 1955, HOUSSAY 1955).

In the present investigation a great difference in buffer capacity was established between the two experimental beverages, which both showed an acid reaction as such (p. 116). The buffer capacity of the beer dosis was nearly 1.000 times that of the brandy dosis (at pH 7 and at 25° C). It is possible that this difference, after all, has some significance as a factor producing different rates of evacuation in the brandy and beer experiments as stated by the earlier investigators (HAGGARD, GREENBERG and COHEN 1938, etc.), and its partial responsibility for the different rates of absorption would thus not seem inconceivable.

Comments. — It can be noted as a compound result of the present comparative investigation relating to the changes in blood alcohol and to the motility of the stomach that brandy has produced, in every component study, a blood alcohol curve with a steeper initial rise and higher peak level than beer, and that the evacuation of the stomach has been distinctly slower and pylorospasm distinctly more frequent in the beer experiments than in the brandy experiments. The explanation suggested by previous investigators that the differences in the above-mentioned respects between distilled and brewed beverages would be due, among other things, to differences in their buffer capacity seems reasonable in the light of the present observations.

533. CIRCULATION

In the experiments of the A_1 as well as the C series, pulse rate and blood pressure were recorded at certain definite times.

The determination of the pulse was made from the radial artery, from a 30-second count, and that of the blood pressure with the aid of a mercury column manometer, the readings being taken with an accuracy of 5 mmHg.

The experimental subjects were not in the so-called basal state in either series, as would have been necessary in order to make generalizable observations. However, since at least the external conditions of experiment were the same in each case under comparison, some inferences can be drawn from the results of experiment if appropriate care is exercised in their scrutiny.

No significant differences in pulse rate were observed between the brandy and beer experiments.

Both in the brandy and the beer experiments a decrease, though nonsignificant in the brandy experiments, of systolic and pulse pressure from their initial values was observed; these changes were significantly stronger in the beer experiments than in the brandy experiments.

Even in the beer experiments the effects were of an unimportant order of magnitude and additional experiments should be carried out in order to determine whether such changes will be found at all under so-called basal conditions. It was not possible in this investigation, in want of such control groups which would not have been administered any beverage at all, to check on the influence of potential factors associated with the experimental conditions themselves (such as adaptation after a preceding working-day to the varying conditions of rest and function in the experiment).

Since no significant differences could be noted in the experiments of the C series between the effects of beer and of an alcohol solution of 3.2 per cent by weight, it is conceivable that in the experiments of the A_1 series, too, at its comparison with brandy, the beer may have acted in the manner of a dilute alcohol solution.

The results relating to pulse rate and blood pressure of the present investigation can thus only be ascribed an indicative, not a demonstrative significance, yet the differences established in comparison are manifest in a manner which makes it appear worth while to suggest their checking by means of further investigation.

Static ataxia. Swaying. — The study relating to static ataxia, in which the swaying of the experimental subjects was mechanically recorded in two mutually perpendicular directions and the component motions were combined by computation to one resultant, yielded the following results of comparison: Brandy caused a strong swaying reaction, the highest disturbance being observed at 60 minutes, at which time also the range of variation of the recordings was at its greatest. After the observed peak, the disturbance declined continuously towards the end of the experiment. In the beer experiments the swaying reaction was much less and it had a peak at 120 minutes, even this value not significantly different from the initial value at 0 minutes. The range of variation, slightly larger at 0 minutes than in the brandy experiment, did not show any increase in the beer experiments as it did in the brandy experiments. The swaying caused by brandy was stronger than that caused by beer throughout the experiment; the mean of the differences was not significant at 120 minutes, although showing the same tendency even here.

The brandy experiments have been carried out before the beer experiments and it could thus be expected that the performance in the beer experiments would be improved due to an effect of learning, but this does not appear likely, at least not in a degree of any noteworthy influence upon the results, for the following reasons: The initial performances (at 0 minutes) in both experiments were not significantly different, and the function concerned is one which is not likely to improve considerably through the effect of learning. Moreover, all experimental subjects were moderate users of alcohol, and the experimental inebriation produced with brandy cannot thus have been a first-time intoxication with exceptional significance in regard to the symptoms of intoxication to them. The theoretical possibility of habituation is hardly deserved of serious discussion in this connection. With a view to obtaining even formally an undisputable result, it would be well either to use a control group, or to carry out the experiments in inverted order with one half of the experimental population.

According to the results of GOLDBERG (1943, 1951), the disturbance recorded in standing steadiness studies, when expressed

by means of its logarithm, shows a linear relation with the blood alcohol in experiments with brandy as well as with brewed beverages.

In the present investigation, as has been stated on p. 120, the relation between swaying reaction and blood alcohol did not appear similar in the brandy and beer experiments: Dependence could be noted in a certain degree in the brandy experiments between the mean values of the disturbance and those of the blood alcohol, but this was not the case in the beer experiments. The differences in swaying observed between brandy and beer cannot thus be explained merely on the basis of the different blood alcohol levels, as has already been pointed out in connection with the question of individual correlation (p. 62). It is possible that the higher rate of increase of blood alcohol in the brandy experiments constitutes the main factor producing this difference, but the temporal restrictions imposed by the method of recording employed in this work preclude any calculation of this factor (cf. p. 120). However, as has been said before, such an assumption would be in agreement with the observations of numerous aerlier investigators (cf. p. 118, 119); it has also been pronouneed by GOLDBERG (1951).

Manual coordination. — The finger-finger test was performed twice, at first in the A_1 series and later with an improved method in the A_2 series.

The second set of finger-finger tests was carried out according to GOLDBERG's original method in which each test consists of 50 stabs and which has proved more sensitive. At 60 minutes a significantly stronger disturbance was observed in the brandy than in the beer experiments, the latter showing a more prolonged disturbance, as opposed to its decrease in the brandy experiments after 60 minutes. At later points of time the disturbance was significantly greater in the beer than in the brandy experiments. The range of variation was wider in the brandy experiments at 60 minutes. An impairment towards the end of the beer experiment could also be noted in regard to some other functions, and it is possible that it is due, in part at least, to lack of initiative caused by the weariness and unwillingness towards the tests observed at the latest stages of the beer experiments. The author

considers the test dependent on psychic attitude, enterprise and other similar characteristics of the subject to such an extent that the reliability of the results is dubious (cf. GOLDBERG 1943, ALHA 1951).

Manual dexterity. — In the Santa Ana dexterity test, which from a neurological point of view corresponds to a multi-dimensional, sensomotor functional entity based on visuo-manual coordination ability, the following results were obtained:

Brandy caused during the first hour of the experiment an impairment of results significantly stronger than that in the beer experiments, which did not manifest itself significantly at all. The recovery was more rapid in the brandy experiments, and also in this respect the difference against the beer experiments was statistically significant. The obtained result was quite distinct and it could be observed both with the uncorrected experimental values and with those corrected in regard to the potential effect of learning. The result can therefore be considered fairly reliable.

The similarity in level of the initial experimental results prior to ingestion of the experimental beverage has been considered to signify that no essential effect of learning between sessions has been present. Although the corrections applied to the results probably have not been able to account exactly for all possible effects of learning, it has to be considered that the correction for training has been more than ample at all events since the time interval between the control experiments was shorter (see p. 25). Consequently the superiority of the disturbance caused by brandy to that resulting from beer can be said to have been established with great reliability.

It remains still to decide whether an impairment of the neurological dexterity performance entity itself is concerned, or an effect of reduced enterprise and interest in the test. seems probable that at least in the brandy experiments a decrease of performance ability has been present, which, again, can have had relation to several elementary neurological functions. Particular attention should be paid to the fact that an abrupt impairment occurred in the brandy experiments at the particular time when the recorded blood alcohol was at its highest and when, for instance, the swaying reaction was strongest. Further, that after this im-

pairment a remarkable improvement was recorded and that no indications of reduced enterprise and interest were observed at this point in the tests.

In the beer experiments, at least at 120 minutes no strong signs could be observed as yet of the lessening of initiative apparent towards the later stages of the beer experiments. The performance in the brandy experiments had already clearly improved in comparison with that in the beer experiments at this particular time. However, no definite conclusions can be drawn in regard to the factors responsible for the slow recovery in the beer experiments and to the part of the functional performance entity which is primarily affected.

The different findings with regard to the correlation between performance and blood alcohol in the brandy and beer experiments have been discussed before (p. 121).

Finger dexterity. — The finger dexterity test, which is primarily a method of investigation recording more refined sensomotor performance, and also based on visuo-manual coordination ability, rendered the following results:

In the brandy as well as the beer experiments a significant impairment of results occurred in the experiments, but no statistically significant difference between the effects of the two beverages could be established. During the second hour the performance improved significantly in the brandy experiments, whereas no similar improvement could be noted in the beer experiments. However, no diversity with regard to the rate of improvement could be established statistically.

It is not impossible that the ability of performance concerned in this test, which may be more strongly dependent on cortical functions than the other sensomotor test performances (see e.g. Foerster 1936, Himwich 1956), has been damaged to such an extent even by the influence of beer in the initial phase of the experiment that no significant difference can develop in comparison with the brandy experiments. On the other hand, brandy may have caused a paralyzing, toxic after-effect on the ability concerned (see e.g. Graf 1933) of such strenght that recovery cannot take place with significantly greater speed as compared with the beer experiments as it has done in the other dexterity test.

The correlation between the results and the blood alcohol values has been discussed before (p. 121).

Comments on sensomotor functions. — As a synopsis of the results relating to sensomotor functions, it can be stated that a more marked disturbance is present in the brandy experiments in the swaying, finger-finger and manual dexterity tests. A more rapid recovery has also been noted in the brandy experiments in the finger-finger test and in the manual dexterity test.

A smaller functional disturbance in the beer experiment has thus been observed in the swaying test, in the finger-finger test particularly at the beginning of the experiment, and in the manual dexterity test.

In the beer experiments the observed disturbance has been more prolonged in the finger-finger test and the manual dexterity test. (Slight signs of this can be surmised also in the finger dexterity test.)

GRAF (1930), in his investigation on coordination, has similarly found the functional disturbance caused by beer to be slighter but more prolonged than the effect of French brandy, which abated more rapidly in spite of its greater strength. ALHA (1953), too, has found a more prolonged disturbance of the functional ability of stenographers by beer than by brandy. The present results appear to be similar to those of BJERVER et al. (1950) and GOLDBERG (1951) in that the disturbances caused by brewed beverages were smaller as a rule: however, the relationship between the various functions and blood alcohol did in this investigation not show common regularity.

Intellectual performance. — In the experiments of the A_1 series the intellectual performance was studied by means of the so-called square test (p. 81), which correlates with the WECHSLER — BELLEVUE block design test, form I: $r = 0.75$.

On the basis of the uncorrected results no significant differences can be observed between the brandy and the beer experiments, nor could any significant changes be observed in either series.

Upon correction on the basis of the results of the control group, the results show a more marked impairment in the brandy experiments during the first hour. Both in the brandy and the beer series the improvement of the results in a manner corresponding to that observed in the control series had been inhibited.

The disturbance was at its greatest at 120 minutes in both series.

The disrurbance has persisted for a long time in the brandy as well as the beer experiments, thus causing an inhibition of recovery. No correlation was observed between the mean disturbance and the mean blood alcohol figures (p. 123). The range of variation was not markedly different in the brandy and beer experiments.

It is difficult to find in the earlier literature any appropriate counterparts to this investigation. In their comprehensive survey of earlier psychological investigations relating to intoxication with alcohol, JELLINEK and MCFARLAND (1940) note the lack, among others, of comparisons between various beverages.

In GOLDBERG's investigation on brewed beverages (1951) the BOURDON test was performed similarly as in his earlier investigation (1943), but in the first mentioned publication merely the fact of the performed test and its result has been stated; this result was reported to have been such as to support those obtained by other means (flicker fusion test and quantitation cornea reflex method). Driving tests (BJERVER and GOLDBERG 1950), too, involve so many different psychic functions that no comparison is possible at least in the aspect concerned in this investigation, even though the investigators have studied the correspondence between such investigations and certain more clearly defined laboratory investigations. According to GOLDBERG, the logarithm of the functional disturbance in psychological tests (Bourdon test) is linearly related to the blood alcohol (when in agreement with the »overall» result). The results of this investigation show no correlation between the functional disturbances and the blood alcohol.

In earlier investigations (KRAEPELIN 1924, GYLYS 1927), in which the effects of alcohol solutions of 10 and 30 per cent upon the ability to do sums, upon comprehension and upon learning, etc. were compared, a more marked effect of the stronger solution upon intellectual performance was noted, whereas the effect of the weaker solution persisted longer.

The differences in the effect upon intellectual functions remain somewhat indeterminate, as is borne out by the fact that different results were obtained if the correction based on the results from the control group was applied in different manners. If the mean results of the control group are used as such, a significantly greater impairment is found to have occurred in the beer experiments during the second hour than after a correction made as described in the appropriate place (p. 22).

The changes during the first hour, again, show the same direction independent of the correction procedure, and the results relating to the first hour can thus be considered more reliable, whereas the result of comparison relating to the later period should be checked. The discrepancy may be caused by the intervals of different length between the experimental sessions of the experimental groups and the control group, by the sources of error associated with the repetition of the test, or possibly by the small populations of the control as well as the experimental groups proper.

535. CLINICAL OBSERVATIONS

Mood of the subjects. — Alcohol euphoria was more markedly manifest in the brandy than in the beer experiments. Particularly during the phase of increasing inebriation in the brandy experiments a marked exaltation of the mood occurred, although euphoria was observed in the beer experiments as well. The mood contained a stronger erethitic element in the brandy than in the beer experiments, in which the sedative effect of the beer was clearly evident. At the decline of mood towards the end of the experiment greater dysphoria was observable in the brandy experiments, whereas a certain listlessness and lessening of initiative but no marked depressive component could be observed in the beer experiments.

Similar results were found in the comparison between alcohol solution and beer. The subjects who had been given alcohol solution showed a more marked euphoria, while in the beer experiment lessening of initiative and of activity as well as of euphoria could be noted towards the end of the experiment.

The sedative effect of beer is commonly known (e.g. GOLDBERG 1951, SOLLMANN 1950, STEPP 1954, JOSEPHSON 1956).

Physical sensations. — In the brandy experiment the subjects did not complain, as a rule, of any pain or annoyance. A few persons had a slight feeling of nausea at the end of ingestion. In the beer experiment, on the contrary, several subjects complained of a strong feeling of repletion in the epigastrium, and towards the end of the experiment more numerous subjects complained of fatigue in the beer experiment than in the brandy experiment.

The feeling of repletion in the epigastrium in the beer experiment is possibly due to distension of the stomach.

Fatigue in the beer experiments has been observed by many investigators.

In the experiments with water, beer and alcohol solution a similar effect of the beer was observed with regard to feeling of repletion in the epigastrium and to fatigue, which were not as frequently experienced in the water or alcohol solution experiments.

In the dynamometer tests a slight (about 5 per cent) significant decrease of compression force was observed in the beer expeirments at 150 minutes, as compared with the results in the water experiments. This result may be accidental, or it may also be a consequence of the deactivating effect of the beer.

Disturbance of speech. — The disturbances of speech were quite slight. The most marked disturbances occurred at the beginning of the brandy experiment, but the differences between the brandy and beer experiments carry no great conviction.

Colour of the face. — Part of the subjects were somewhat flushed of face both in the beer and the brandy experiments. The method employed was found to be too coarse to allow of the determination of any definite differences between the beer and the brandy experiments.

6. SUMMARY

The aim of this investigation was the comparison between certain neurological and physiological effects of a distilled beverage of 32.6 per cent by weight and a brewed beverage of 3.6 per cent by weight. The experimental dosis was 1 g of absolute alcohol per kg of body weight, ingested upon six hours' fast in equally spaced aliquots within one hour either as undiluted brandy or as beer.

In some of the comparisons (static ataxia, manual coordination, manual dexterity, finger dexterity, intellectual performance) quantitative methods of evaluation have been used, whereas clinical assessment was employed in others.

Blood alcohol. — Several separate comparative experiments included in this investigation have yielded the following common result: The distilled beverages (blended brandy) has significantly produced a rise of the blood alcohol curve at a higher rate and to a higher peak level than beer; about one hour after termination of the ingestion the curves have come together and thereafter maintained approximately the same level during their further descent. As could be expected, a corresponding difference in the rate of increase and the level of the alcohol concentration was found in the cisternal fluid.

The range of variation is of considerable magnitude in the brandy experiments at the end of the first hour of the experiment.

Motility of the stomach. — In comparative experiments with ten subjects, the evacuation of the stomach and the occurrence of pylorospasm under the influence of brandy and beer has been studied by means of an x-ray method, the following very concise result being obtained: In the beer experiments the pylorus was more spastic in nine cases than in the brandy experiments and

the evacuation of the stomach was clearly delayed in nine cases in comparison with the brandy experiments.

In this experimental group, too, the slow evacuation of the stomach in the beer experiments was accompanied by a significantly lower blood alcohol level in the first part of the experiment, as compared with the brandy experiments.

In the discussion, the possible causes of the findings relating to blood alcohol and of the differences in the motility of the stomach have been commented upon. Furthermore, the buffer capacities of the experimental beverages have been determined, and it has been found that the buffer capacity of the beer at pH 7 and 25° C was 100 times that of an equal quantity of the brandy. This finding is in agreement with the conclusions of some earlier investigators (HAGGARD, GREENBERG and COHEN 1938).

Circulation. — Since the subjects were not in a »basal» state during the experiments, the results cannot be generalized with any great confidence. No significant differences were observed in the pulse rate. In the beer experiments a significantly greater decrease of systolic pressure and pulse amplitude occurred. No significant differences were observed between the effects of an alcohol solution of 3.2 per cent by weight and of beer.

Static ataxia. Swaying. — Static ataxia was quantitatively recorded as swaying by means of the modified Romberg test. Brandy caused marked swaying, with a maximum at 60 minutes; this reaction was significantly stronger than that caused by beer. A special feature was the wide range of variation observable in the brandy experiments particularly at 60 minutes. A fairly distinct relationship could be established between swaying and blood alcohol in the brandy experiments, not in the beer experiments. No significant increase of the swaying occurred in the beer experiments. Individual dispersion in the swaying reaction was great.

Manual coordination. Finger-finger test. — In the finger-finger test at 60 minutes a significantly stronger functional disturbance was observed in the brandy experiments than in the beer experiments, in which the disturbance was superior at the later times.

Manual dexterity. — Brandy caused a more marked disturbance in the Santa Ana dexterity test than beer, but the recovery was also more rapid than in the beer experiments. In the brandy experiments a wide range of variation was found at 60 minutes and at the end of the experiment. A slight correlation between the functional disturbance and the blood alcohol seemed to appear in the brandy experiments, not in the beer experiments.

Finger dexterity. — A disturbance both in the brandy and the beer experiments, but no definite difference between the two series, was noted in the O'Connor finger dexterity test. However, a slight indication of a possibly more pronounced recovery during the second hour can be surmised in the brandy experiments; also, a very slight correlation may exist between the mean values of disturbance and blood alcohol in the brandy experiments, not in the beer experiments.

Intellectual performance. — In a non-verbal intelligence test, brandy caused a significantly stronger disturbance than beer during the first hour. The comparison between brandy and beer after the first hour is somewhat uncertain, and it might be well to control the results. No correlation between the mean values of disturbance and the blood alcohol was to observe.

Clinical observations. — In the brandy experiments more marked euphoria was observed, with greater erethism at the beginning, whereas in the beer experiments a pronounced sedative effect could be noted.

In numerous cases beer caused a feeling of repletion in the epigastrium. No one of the subjects complained of this sensation in the brandy experiments. Also a more marked feeling of fatigue was recorded than in the brandy experiments, but the muscular strength had not remarkably decreased.

Speech motorics seemed to be more strongly affected in the brandy experiments, in particular in the early stage of the experiment, but the disturbances were only slight in both series.

The method of assessing the colour of face was found to be too coarse to establish any differences.

In the discussion the qualitative and quantitative properties of the experimental beverages an their differences have been commented upon, as well as the relationship between the various function disturbances observed and blood alcohol.

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8. APPENDIX

TABLE 26. *Age and weight of the experimental subjects*

A_1 *series*			A_2 *and B series*			*C series*			*Cerebrospinal fluid group*		
Experimental subject No.	Age, years	Weight, kg	Experimental subject No.	Age, years	Weight, kg	Experimental subject No.	Age, years	Weight, kg	Subject	Age, years	Weight, kg
1	32	65	1	49	80	1	25	80	L	49	80
2	40	75	2	30	61	2	24	64	M	30	82
3	37	69	3	37	71	3	21	70	K	33	75
4	22	73	4	42	61	4	23	63			
5	32	64	5	30	82	5	20	71			
6	45	77	6	29	66	6	32	61			
7	33	75	7	33	75	7	30	61			
8	26	75	8	53	69	8	32	65			
9	27	63	9	32	61	9	21	75			
10	35	82	10	26	67						
11	39	81									
12	22	80									

TABLE 27. *Blood alcohol, per mil, in the brandy and beer experiments (A_1 series). Individual values*

Experimental subject No.	*Brandy experiments* Time, minutes since commencement of ingestion							*Beer experiments* Time, minutes since commencement of ingestion						
	0	60	90	120	150	180	240	0	60	90	120	150	180	240
1	0.01	1.18	1.38	1.25	1.11	1.02	0.87	0.07	0.85	1.27	1.19	1.09	0.99	0.89
2	0.02	1.20	1.10	1.00	0.90	0.82	0.66	0.04	0.82	0.92	1.02	0.98	0.89	0.74
3	0.04	1.22	1.17	1.02	0.95	0.91	0.77	0.03	1.02	1.10	1.08	0.99	0.92	0.80
4	0.06	2.23	1.61	1.24	1.12	1.08	0.88	0.05	0.98	1.03	1.17	1.14	1.11	1.04
5	0.08	1.40	1.16	1.12	1.10	0.96	0.83	0.03	0.83	0.94	1.02	0.97	0.95	0.84
6	0.13	1.18	1.30	1.18	1.01	0.92	0.88	0.01	0.47	1.03	1.00	0.97	0.87	0.80
7	0.01	0.50	1.07	1.02	0.97	0.92	0.81	0.03	0.81	0.97	1.05	0.99	0.90	0.82
8	0.05	1.40	1.14	1.04	0.90	0.85	0.76	0.03	1.13	1.26	1.23	1.08	0.99	0.88
9	0.07	1.23	1.24	1.03	0.99	0.94	0.78	0.06	1.02	0.97	1.03	1.03	0.98	0.89
10	0.12	1.31	1.28	1.12	0.95	0.95	0.86	0.04	1.09	1.14	1.18	1.15	1.11	0.95
11	0.04	1.04	1.16	0.96	0.89	0.88	0.70	0.05	0.66	0.85	0.89	0.79	0.70	0.64
12	0.04	1.00	1.25	1.14	1.10	0.98	0.83	0.06	0.76	1.07	1.12	1.18	1.08	0.90

TABLE 28. *Results of the swaying test, mm/sec, in the brandy and beer experiments. Individual values*

Experimental subject No.	*Brandy experiments* Time, minutes since commencement of ingestion					*Beer experiments* Time, minutes since commencement of ingestion				
	0	60	120	180	240	0	60	120	180	240
1	9.2	27.6	15.6	9.2	10.6	7.1	10.6	9.9	8.6	7.1
2	8.5	49.5	16.0	21.2	10.8	5.0	7.2	12.5	12.2	8.1
3	6.4	12.0	9.2	7.2	9.4	5.7	6.4	7.2	7.2	6.4
4	10.0	25.6	23.3	12.2	7.8	12.0	13.5	11.4	7.2	7.1
5	9.4	7.2	10.0	7.8	10.3	8.5	5.0	7.8	5.8	6.4
6	7.2	13.6	14.4	14.4	17.5	8.1	10.0	20.0	10.0	9.4
7	7.6	9.4	7.8	8.1	8.1	5.7	9.2	8.1	7.2	6.4
8	9.8	12.0	18.8	11.4	10.0	4.2	8.5	6.4	5.7	5.0
9	11.2	42.5	42.2	31.1	12.5	6.4	13.6	14.4	12.2	10.6
10	11.2	24.4	18.9	12.5	8.9	8.9	11.4	10.0	11.4	12.5
11	10.3	21.1	10.8	13.0	11.4	18.3	10.3	9.4	8.1	6.7
12	9.4	10.0	10.0	11.7	7.2	10.0	7.2	20.0	11.7	8.1

TABLE 29. *Results of the finger-finger test, mm² per stab, in the brandy and beer experiments* (A_2 *series*). *Individual values*

Experimental subject No.	*Brandy experiments* Time, minutes since commencement of ingestion										*Beer experiments* Time, minutes since commencement of ingestion									
	0	10	20	30	40	50	60	90	120	150	0	10	20	30	40	50	60	90	120	150
1	3.8	4.3	5.0	5.5	5.9	5.1	6.0	6.3	4.5	4.5	4.6	4.6	5.0	4.0	7.1	4.8	6.6	4.8	6.2	5.9
2	2.2	2.6	4.0	3.8	3.1	4.0	4.6	3.4	4.1	2.8	2.6	2.7	3.8	3.3	5.1	4.4	3.1	6.1	4.4	5.1
3	2.5	3.4	4.6	3.2	4.4	4.5	6.3	3.7	2.9	3.2	2.4	2.7	3.8	3.2	3.7	4.6	5.5	5.6	4.9	4.3
4	4.1	3.3	5.9	4.7	7.9	8.0	11.3	10.3	8.0	6.3	3.3	4.0	6.8	6.4	5.5	7.9	6.5	8.5	8.6	8.1
5	2.1	2.6	1.6	2.2	3.2	2.4	2.6	2.8	2.9	2.0	1.8	1.9	2.3	1.5	2.4	1.7	2.4	2.3	3.4	3.7
6	2.1	3.0	3.4	4.2	3.8	3.1	5.1	4.2	4.0	4.0	3.2	4.6	4.5	4.2	5.2	3.1	5.2	6.9	4.9	7.3
7	2.1	2.8	2.7	3.4	4.6	6.6	7.0	4.2	3.5	3.2	2.9	3.2	3.2	4.9	3.2	4.1	3.1	5.4	5.4	7.7
8	3.6	3.7	2.8	3.9	3.2	5.1	7.7	6.7	5.1	3.9	3.1	2.8	2.2	3.3	2.8	3.1	3.0	5.1	4.8	3.8
9	2.3	1.4	2.3	1.6	1.9	2.1	2.5	2.2	2.9	2.2	2.2	1.9	2.3	1.8	1.8	2.4	3.6	3.4	3.1	2.8
10	3.2	2.8	4.1	4.8	4.0	8.2	6.2	4.3	4.2	3.4	4.3	2.6	2.9	3.3	4.0	4.8	3.4	3.5	4.4	5.0

TABLE 30. *Results of the Santa Ana dexterity test in the brandy and beer experiments. Individual scores*

Experimental subject No.	*Brandy experiments* Time, minutes since commencement of ingestion				*Beer experiments* Time, minutes since commencement of ingestion			
	0	60	120	180	0	60	120	180
1	91	77	77	84	82	73	77	82
2	97	77	96	93	91	89	90	95
3	86	75	90	87	82	74	81	82
4	103	100	105	113	102	105	109	109
5	71	70	73	81	76	74	78	83
6	66	56	67	66	80	86	78	72
7	87	78	90	96	86	73	73	78
8	91	69	102	110	84	84	81	96
9	82	77	98	102	91	78	91	84
10	81	74	80	78	85	87	75	83
11	75	76	79	91	67	74	71	79
12	81	69	73	91	78	67	77	76

TABLE 31. *Results of the finger dexterity test in the brandy and beer experiments. Individual scores*

Experimental subject No.	*Brandy experiments* Time, minutes since commencement of ingestion				*Beer experiments* Time, minutes since commencement of ingestion			
	0	60	120	180	0	60	120	180
1	56	40	47	43	52	41	45	47
2	42	35	36	26	62	54	55	60
3	49	53	59	60	50	43	48	43
4	53	48	63	60	72	55	52	60
5	36	33	41	40	49	49	50	52
6	45	41	34	44	62	43	32	29
7	48	41	49	44	48	39	47	47
8	58	42	52	53	55	53	57	58
9	48	45	48	45	55	46	61	60
10	59	49	54	54	64	56	60	59
11	49	40	51	55	41	49	46	51
12	51	42	52	60	52	47	49	53

TABLE 32. *Results of the square test in the brandy and beer experiments. Individual scores*

Experimental subject No.	*Brandy experiments* Time, minutes since commencement of ingestion				*Beer experiments* Time, minutes since commencement of ingestion			
	0	60	120	180	0	60	120	180
1	11	15	13	9	15	11	18	18
2	12	12	8	15	7	9	8	14
3	8	11	8	9	9	12	5	14
4	9	7	10	17	10	12	13	9
5	8	10	6	9	4	5	10	11
6	8	11	8	5	7	6	8	7
7	13	6	6	8	14	6	8	5
8	10	10	4	9	6	10	8	12
9	14	10	15	16	17	18	17	18
10	2	7	12	6	11	15	10	13
11	17	14	18	18	12	17	14	17
12	18	15	18	18	18	18	18	18

T. A. Pihkanen NEUROLOGICAL AND PHYSIOLOGICAL STUDIES ON DISTILLED AND BREWED BEVERAGES

ERRATA

The following errors have been noticed and should be rectified by the reader:

Page	7	line 9 ult.	evalution	*read:*	evaluation
	15	8	in reaction time		in relation to time
	15	4 ult.	evalution		evaluation
	20	3	evalution		evaluation
	26	9 ult.	CO_2 ..... 4.0		CO_2 ..... 0.4
	28	equation (4)	d		$\bar{d}$
	39	Table 3	*Reverse the line headings* »Mean error» *and* »Stand. deviation»		
	62	line 11 ult.	seriesat	*read:*	series at
	77	1 ult.	*after* significant	*add:*	except between 0 and 60 minutes
	82	7	reapted	*read:*	repeated
	87	4 ult.	evalutions		evaluations
	116	3	*after* 38.2 per cent	*add:*	of the ash
	132	20	aerlier	*read:*	earlier
	132	21	pronouneed		pronounced
	133	8 ult.	seems		It seems
	136	2	disrurbance		disturbance
	136	17	quantitation		quantitative
	138	9	expeirments		experiments

In the tables the notation »Mean error» refers to the standard error of the mean.